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ALLOY

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My invention relates to alloys and more particularly to an alloy having a beryllium-copper base which is ideally adapted for casting by sand, die or centrifugal methods.

In my prior Patent No. 2,270,660, issued January 20, 1942, I have described an ordnance alloy utilizing relatively large amounts of beryllium-copper and relatively small amounts of aluminum and mercury. Heat treatment of the material during formation of the alloy was such that sufficient mercury was retained in the metal to cause the metal to resist the corrosive action of mercury fulminate. I have found however, that many uses for which metal having a beryllium-copper base is desirable, do not require any large amount of mercury therein.

My present alloy differs from the alloy described in my above cited patent in that in the present instance I prefer to utilize lesser amounts of mercury, or even no mercury at all, and to incorporate nickel in the alloy for the main purpose of aiding, along with the aluminum, in forming a grain structure which is more dense than when either aluminum or nickel are used separately with beryllium-copper. Furthermore, I have found that the higher melting point of nickel, combined with the aluminum, increases the temperature range of the beryllium-copper base between the liquid and solid state. I find that the combination of nickel and aluminum with the beryllium-copper in the alloy so increases the range between the liquid and the solid state, that various production methods such as centrifugal casting, extruding and molding and die-casting, or sand-casting, can be more readily accomplished because of the fine grain and advantageous pouring characteristics, resulting in a smoother and more perfect part. This is a distinct advantage in that in many cases, it is possible to use the surface created by the mold as a finished surface.

In the past other alloys of beryllium-copper have been found to be difficult to handle in casting, and foundry trouble has discouraged in many cases the used of beryllium-copper alloy. The range I obtained by the addition of aluminum and nickel to the beryllium-copper base between the liquid and solid state of the material greatly simplifies its handling characteristics by causing the material to fill the mold to a better advantage and to stay molten and plastic for a longer period. As a result of this in sand and in centrifugal casting, I can maintain a homogeneous condition in the material for a longer period and therefore I have a greater latitude in handling the material.

Likewise in extruding, molding or die-casting the material in a mushy or plastic condition, the alloy can be utilized in parts which have a great deal more detail than formerly, and yet the parts can be fabricated with positive accuracy.

Furthermore I have found that the surface of my beryllium-copper aluminum-nickel alloy will work-harden in use. Consequently the material has ideal characteristics for use as bearings, and will stand greater amounts of wear than beryllium-copper alone. Consequently my beryllium-copper aluminum-nickel alloy is ideally adapted for example, for use as clutch-bearings, facing for fuel pumps, and more important, for use in gun-mount tracks where steel rollers are used coming directly in contact with the surface of the material. Wear is eliminated and a minimum of oil or lubricant is required. I have found that due to the nickel and aluminum additions the alloy has the property of operating for longer periods even when running dry.

In addition the present alloy has greater resistance to corrosion than beryllium-copper itself. This is particularly important where parts are to be cast, extruded or molded to size, and are to be heat-treated thereafter. Many beryllium-copper alloys are known to oxidize and scale which destroys the surfaces when parts are heat-treated. The new alloy disclosed herein does not scale and therefore increases the use of beryllium-copper for parts where heat treatment is to be carried out, and particularly when the surfaces are not to be machined after heat treatment. The above advantages of the alloy about to be described herein have enabled me to substitute beryllium-copper for many parts where steels have been previously utilized. A preferred alloy comprises the following ingredients:

	Percent
Copper-----	60 to 93
Beryllium-----	.10 to .11
Nickel-----	.55 to 7
Mercury-----	.0 to .15
Aluminum-----	1 to 20
Arsenic-----	.10 to 2

Alloys within the above ranges are especially suitable for all casting methods for the reasons given above. They have sufficient strength to be in many cases substituted with equal or even greater tensile strength for parts heretofore made of steel by machining, stamping, or forming.

The beryllium-copper used as a base alloy is usually purchased as a concentrated product. I add thereto pure copper to establish the cor-

rect percentage for the type of alloy to be formed. The following procedure is followed in forming an alloy within the range of ingredients given above.

An amount of pure copper is placed on the bottom of a melting pot, on top of which is placed the arsenic and then copper nickel shot, then more pure copper. Graphite is generally added to assist in cleaning these ingredients as they are being alloyed. Heat is then applied to the mix and is increased slowly at first. The pre-heated beryllium-copper concentrate is then added very slowly so that the copper nickel arsenic will remain molten at all times through the process of alloying. When molten, the mixture requires some agitation to accomplish the best interaction of the ingredients. The temperature may then be dropped to retain the molten liquid at about 50° C. over the freezing point of the melt, which changes with the variations in the alloy, in preparation for the addition of the aluminum, and the mercury, if used. If no mercury is utilized the aluminum is then added to the melt.

If however, it is desired to utilize mercury in the small quantities disclosed herein, an aluminum-mercury alloy is made by placing mercury in contact with aluminum foil, for example, for at least twenty-four hours. Inasmuch as excess mercury over the stable mercury-aluminum alloy will pass out of the melt there is no necessity for a careful proportioning of the mercury. The amount of aluminum foil used, however, in making the mercury alloy will determine the amount of mercury held in the final alloy. The aluminum-mercury alloy may then be added to the melt, together with the proper amount of additional aluminum necessary to make up the required aluminum percentage. The aluminum or the aluminum and mercury is thoroughly mixed with the first alloy at the maintenance temperature to distribute the aluminum or the aluminum-mercury materials throughout the melt. If mercury is used, before the aluminum-mercury amalgam is entirely melted the heat of the mix is preferably increased and held at a higher value. This temperature will vary with the various alloys, and the conditions of the metal being processed. During this time mercury vapor from the excess mercury is expelled. This metal is then cast in suitable slugs for use in casting or extrusion molding. If desired, the melt can be raised to a temperature sufficient only to remove excess mercury added along with the aluminum-mercury alloy, or if desired the temperature can be still further increased to remove all of the mercury, the aluminum foil in this case acting merely as a carrier to enter the mercury into the melt. Consequently no mercury will be, under these conditions, carried through to the

final alloy. I do not therefore, wish to limit myself to being required to use mercury in the alloying of the beryllium-copper-aluminum-nickel.

When casting by any of the methods above mentioned, the final alloy produced is readily maintained in a plastic state over a relatively wide range of temperatures and is easily cast or molded at high temperatures and pressures.

The presence of the aluminum as such in the final alloy aids in making the alloy plastic and somewhat improves the molding properties of the alloy.

The arsenic sublimes and leaves a dark, solid formation in the pot which serves as a cleaner along with the powdered graphite added for the same purpose. The combination of the nickel and the aluminum, however, is the most important addition to the alloy, in that it provides all of the advantages set forth above in discussing the use of the material.

I claim:

1. A fine grain beryllium-copper base alloy capable of being cast and of work hardening on the surface thereof and having a tensile strength comparable to that of steel, essentially consisting of:

	Per cent
Copper -----	60 to 93
Beryllium -----	.10 to 11
Nickel -----	.55 to 7
Aluminum -----	1 to 20
Arsenic -----	.10 to 2

2. A fine grain beryllium-copper base alloy capable of being cast and of work hardening on the surface thereof and having a tensile strength comparable to that of steel, essentially consisting of:

	Per cent
Copper -----	60 to 93
Beryllium -----	.10 to 11
Nickel -----	.55 to 7
Aluminum -----	1 to 20

and to which mercury in amount not exceeding 0.15% is added during the melting operation.

3. A fine grain beryllium-copper base alloy capable of being cast and of work hardening on the surface thereof and having a tensile strength comparable to that of steel, essentially consisting of:

	Per cent
Copper -----	60 to 93
Beryllium -----	.10 to 11
Nickel -----	.55 to 7
Aluminum -----	1 to 20
Arsenic -----	.10 to 2

and to which mercury in amount not exceeding 0.15% is added during the melting operation.

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