

UNITED STATES PATENT OFFICE

1,975,115

ARTICLE SUBJECT TO ABRASION

Georg Masing, Berlin, and Otto Dahl, Berlin-
Charlottenburg, GermanyNo Drawing. Application October 22, 1931,
Serial No. 570,506. In Germany May 21,
1926

10 Claims. (Cl. 148—32)

This invention relates to improvements in articles subject to abrasion; and it comprises certain articles used in mechanical and electrical machinery, technical equipment, instruments of precision, etc. where parts are exposed to mechanical wear and to frictional contact; the said articles being fashioned from copper-beryllium alloys, containing copper as a major component with sometimes a small proportion of other alloying materials, and being heat hardened; the compositions of the alloys and the heat treatment of the articles being conditioned largely by the properties of hardness, strength, durability, etc. desired in the finished articles; all as more fully hereinafter set forth and as claimed.

In a prior and copending application, Ser. No. 191,263, filed May 13, 1927, of which the present application is a continuation in part, we have described methods for heat treating copper-beryllium alloys and the properties of various alloys of this type; the alloys being specifically described and claimed. The present application is directed to articles produced from the same type of alloys, the said articles being such as are subject to mechanical wear and abrasion in use.

In the technical arts there are many parts of machines, instruments, etc. which are subject to abrasion and mechanical wear in use. This is especially true in the construction of electrical machinery. While many metals and alloys have been suggested for such use, there is none which fully combines the properties of hardness with suitable anti-friction and other characteristics. In many uses the alloys to be employed must also exhibit corrosion resistant properties.

While various alloys of beryllium have been described in the art, but little has been published concerning their properties. We have found that certain of these alloys have properties which make them particularly adapted for technical uses in which resistance to abrasion is important. Beryllium is one of the lightest metals employed technically and it is a good hardening agent in alloys. The hardness imparted to an alloy by the introduction of small proportions of beryllium is characteristic. Copper hardened by alloying with beryllium is a particularly useful material for the technical purposes in question. By the methods hereinafter described certain properties of the copper-beryllium alloys may be varied at will. For example, the hardness may be increased to that of hardened steel or reduced to a point at which the alloys may be readily worked.

The articles, in the construction of which the

copper-beryllium alloys are particularly suitable, are numerous and of various types. The hardness of the alloys and their "anti-friction" properties adapt them for bearings, journals and rotating shafts. We have found that the alloys make excellent bearing metals. Various other parts subject to friction can likewise be made. These parts include pivots, pins, links, knife edges, slide blocks, slides, cups and cones of cycles, etc. The low specific electrical resistance of the alloys and their lightness adapt them for various parts of electrical equipment, such as slip rings, commutator bars, contact points in circuit breakers, various sliding contacts, etc. In fact these alloys are suitable for the construction of any parts which are subject to abrasion, to frictional wear and to corrosion.

The copper-beryllium alloys with which the present invention is most particularly concerned have a beryllium content ranging from about 0.3 up to 12 per cent; the residue being copper or mainly copper. These alloys can be roughly divided into two ranges (1) alloys from which the so-called "beta modification" separates from the melt and (2) alloys where the beta modification does not separate from the melt. It may be said that the beta modification separates upon solidification of alloys having, roughly, a beryllium content of from 5 to 12 per cent, while alloys having a lower content do not show such a separation. The lower limit of the existence of the beta modification, however, is altered by the presence of other alloying materials; which, to that extent, reinforce the hardening action of beryllium. Thus, in some instances, the beta modification has been found to exist in compositions representing a beryllium content of as low as 3 per cent, when these other materials were also present.

We have found that these copper-beryllium alloys may be hardened by a two-step process comprising heating at an elevated temperature for some time, followed by quenching and "age-hardening" or tempering at a lower temperature for a time sufficient to improve their properties. But each heating stage is severally useful with these alloys under some circumstances.

Alloys having a beryllium content too low to permit the existence of the beta modification, that is a beryllium content, roughly, below 5 per cent, are advantageously hardened by heat treating at temperatures above a certain transition point, which appears to lie at approximately 580° to 600° C. followed by ageing or age-hardening below this temperature. For example, the

alloy may be first heated at any convenient temperature between the transition point and the melting point, that is, advantageously above 600° C., followed by cooling. Small pieces cool with sufficient rapidity in the air while large pieces should be quenched. This annealing operation leaves the metal in suitable condition for fabricating various articles of the nature of those in which we are interested. This may be followed by a prolonged heating at temperatures below the transition point, such as from 150° to 500° C. This heating is continued for a time sufficient to improve the properties of the alloys. At the lower temperatures several days may be required for this treatment, while at 300° C., two hours is sufficient. In a specific example of such a heat treatment, a bearing having a composition of 97 per cent copper and 3 per cent beryllium and having an initial hardness of about 125° Brinell, after heat treatment was found to have a final hardness of about 360° Brinell.

Throughout the range of the existence of the beta modification the heat treatment required to produce the maximum hardness comprises merely the first step of the above described process, namely a heating to temperatures above the transition point followed by quenching. The second step, namely heating below the transition point may be employed to obtain the alloy in a relatively soft and mechanically workable condition.

In one case a small axle for a scientific instrument was cast from a copper-beryllium alloy containing 6.7 per cent of beryllium. The chilled casting was found to have a hardness of 490° Brinell. Upon a prolonged heat treatment at temperatures below 580° C., the hardness of the above mentioned casting was reduced to about 240° Brinell. This latter treatment increased the ductility and toughness of the alloy and it could be worked readily. While in this condition, the casting was turned down to size and finished. It was then hardened by heating somewhat above 600° C. and quenching. Its final hardness was 730° Brinell.

The above described heat treatments can be applied to both cast and to mechanically worked articles. In the case of cast articles the heat treatment at the higher temperatures, when the two-step process is being employed, may usually be obviated, the cooling in the casting taking the place of this treatment.

For the production of alloys having intermediate properties between the extremely hard and the workable types there are two methods available. The first method consists in a heat treatment at intermediate temperatures, for example between 450 and 600° C. The second method consists of a prolonged heat treatment at somewhat lower temperatures. This latter procedure is somewhat similar to the final step of the usual two-step process. A preliminary mechanical working operation is frequently advantageous before the heating step.

The first effect of a prolonged heating at temperatures below the transition point is to harden the alloy, but this is followed by the production of high ductility and toughness as well as a high tensile strength. Since the heating may be interrupted at any point, it is possible in this way to produce alloys having, within wide limits, almost any desired properties. Definite values of hardness, ductility, toughness and strength may be produced. These properties of the alloys can therefore be adjusted to the optimum values re-

quired for the articles in question. Somewhat similar results to the above may be obtained by heating the alloys above 600° C. followed by a slow cooling. This method is not so conveniently controlled, however.

In one particular example of the above heat treatment a copper-beryllium article, with a beryllium content of 2.5 per cent was heated at 500° C. for some time. It was then found to possess a notched bar toughness of about 15 meter-kilograms per square centimeter and a tensile strength of 75 kilograms per square millimeter. This same article, after being treated by the two-step process, namely by heating above 600° C. and then at temperatures in the neighborhood of 450° C., gave a notched bar test toughness of only 1 meter kilogram per square centimeter and was found to have a tensile strength of 140 kilograms per square millimeter. It has been found that advantageous results with the described single heating at the lower temperatures are only obtained when the beryllium content of the alloy amounts to at least 1 per cent.

The effect of added metals upon the properties of the alloys and upon the heat treatments required is very striking. The addition of up to 1 per cent of phosphorus has been found to produce a considerable reduction in the amount of beryllium metal required to produce certain improved characteristics; as stated, in the presence of a little beryllium, it reinforces the characteristics of the latter. In a sense, it then acts as a substitute for beryllium. The time required for heat treatment is reduced by the presence of phosphorus. Other metals such as tin, aluminum, zinc, silver and magnesium may be present simultaneously in the alloy as, so to speak, beryllium assistants, with the production of improved properties.

A typical heat hardening process, as carried out with a bearing containing 0.25 per cent of phosphorus and about 1.5 per cent of beryllium, was carried out as follows: The bearing was heated above the previously mentioned transition point, in this case at 800° C., and then quickly cooled. After cooling its hardness was found to be only 80° Brinell. By subsequently tempering the alloy by heating for an hour at 350° C., the hardness was found to have increased to 210° Brinell. This bearing was found to have an exceptionally low coefficient of friction against steel.

In comparison with the above, when a copper-beryllium alloy of the same beryllium content but free from phosphorus was treated in the same manner, the hardness, on cooling from 800° C., was found to be 74 units and, upon heating for as long as 7 hours at 350° C., the hardness increased only 20 units. The beneficial effects of the phosphorus addition is evident.

The beryllium content can be reduced without detriment when addition metals, such as aluminum, tin, silver and magnesium are present. Alloys of this type contain up to about 2.5 per cent of beryllium, a somewhat larger per cent of one of the addition metals and a preponderating amount of copper; 5 to 10 per cent of addition metal, for example, produces desirable results.

We have found that the addition of metals other than copper and beryllium permits the reduction of the beryllium content to a fraction of the amount required when only copper and beryllium are employed. Since beryllium is by far the most expensive of the metallic constituents, a reduction in the quantity required is advanta-

geous. For example, when copper only is alloyed with the beryllium, at least 1 per cent of beryllium must be present in order to give an alloy with a high degree of hardness. But, upon the addition of from 5 to 25 per cent of one of the other metals mentioned, the beryllium content may be reduced to about 0.3 per cent to obtain the same degree of hardness.

The heat treatment required for these multi-component alloys is the same as that described previously. The two-step process is advantageous.

The properties of the above described copper-beryllium alloys, including within this term alloys which may contain one or more addition metals, adapt them particularly for the uses outlined previously. Probably their most important use is in electrical instruments of various types, for example in knife switches, commutator bars, slip rings, bearings, sliding contact points, etc. Many of the metals now in use for such parts corrode in sea air, for example. The above described alloys offer excellent resistance to such corrosion; this being a further advantage derived from their use.

By the term "balance substantially copper" occurring in the claims, we mean that the alloy article called for may also contain small amounts of addition metals such as phosphorus, tin, zinc, iron, cobalt, and aluminum, these metals occurring in quantity insufficient to substantially alter the characteristic properties of the said alloy articles.

What we claim is:

1. An improved article adapted to resist abrasion and suitable for use as a knife switch, commutator bar, slip ring, bearing, electrical contact, rotating shaft, journal, pivot, pin, knife edge, slide block, etc. comprising a heat hardened copper-beryllium alloy containing from about 0.3 to 12 per cent of beryllium with the remainder substantially copper, said article having hardness and other mechanical properties obtained by heating said copper-beryllium alloy to temperatures somewhat above a transition point lying in the neighborhood of 580° to 600° C., cooling, and age-hardening at elevated temperatures above about 150° C. but below said transition point.

2. An improved article adapted to resist abrasion and suitable for use as a knife switch, commutator bar, slip ring, bearing, electrical contact, rotating shaft, journal, pivot, pin, knife edge, slide block, etc., comprising a heat hardened copper-beryllium alloy containing from about 0.3 to 12 per cent beryllium with a remainder substantially copper, and also containing from about 0.1 to 1 per cent of phosphorus reinforcing the hardening effect of the beryllium.

3. An improved article adapted to resist abrasion and suitable for use as a knife switch, commutator bar, slip ring, bearing, electrical contact, rotating shaft, journal, pivot, pin, knife edge, slide block etc., comprising a heat hardened copper-beryllium alloy having a beryllium content above about 0.3 per cent but below percentages at which

the beta-modification separates upon solidification, ranging from about 3 to 5 per cent by weight, with a balance substantially copper, said article having hardness and other mechanical properties obtained by heating said copper-beryllium alloy at temperatures below its melting point but above about 600° C. and age-hardening by prolonged heating at temperatures ranging from about 150° to 500° C.

4. The article of claim 3 wherein said heat hardened copper-beryllium alloy also contains phosphorus ranging from about 0.1 to 1 per cent by weight.

5. An improved article adapted to resist abrasion and suitable for use as a knife switch, commutator bar, slip ring, bearing, electrical contact, rotating shaft, journal, pivot, pin, knife edge, slide block etc., comprising a heat hardened copper-beryllium alloy containing sufficient beryllium to cause separation of the beta modification upon solidification, ranging from about 3 to 12 per cent by weight, with a balance substantially copper, said article having hardness and other mechanical properties produced by heating said copper-beryllium alloy at temperatures below its melting point but above about 600° C. and quenching.

6. The article of claim 5 wherein said heat hardened copper-beryllium alloy also contains phosphorus ranging from about 0.1 to 1 per cent by weight.

7. An improved article adapted to resist abrasion and suitable for use as a knife switch, commutator bar, slip ring, bearing, electrical contact, rotating shaft, journal, pivot, pin, knife edge, slide block, etc. comprising a heat hardened copper-beryllium alloy containing from about 0.3 to 12 per cent of beryllium with the remainder substantially copper, said article having hardness and other mechanical properties produced by chill-casting said copper-beryllium alloy and age-hardening by prolonged heating to temperatures between about 150° and 500° C.

8. The article of claim 6 wherein said heat hardened copper-beryllium alloy also contains phosphorus ranging from about 0.1 to 1 per cent by weight.

9. An electrical contact comprising a heat hardened copper-beryllium alloy containing about 0.3 to 12 per cent of beryllium with a balance substantially copper, said contact having hardness and other mechanical properties produced by heating said copper-beryllium alloy to temperatures somewhat above a transition point lying in the neighborhood of 580° to 600° C., cooling and age-hardening at temperatures above about 150° C. but below said transition point.

10. The contact of claim 8 wherein said heat hardened copper-beryllium alloy also contains phosphorus ranging from about 0.1 to 1 per cent by weight.

GEORG MASING.
OTTO DAHL.