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ALLOY

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The present invention relates to a new and useful alloy and relates particularly to an alloy containing as essential components boron, zirconium, tungsten, chromium, iron and cobalt.

This application is a continuation in part of my co-pending application Serial No. 115,816, filed December 14, 1936, which in turn is a continuation in part of my application Serial No. 20,050, filed May 6, 1935, the subject matter common to all of these applications being now claimed herein.

An object of the present invention is to provide an alloy having certain inherent physical properties and characteristics which can be developed and controlled by means of thermal treatment. Another object is to provide an alloy which can be manufactured in finished or semi-finished forms by means of centrifugal casting.

The alloy of the present invention has a combination of physical properties and characteristics which render it especially valuable for use as metal cutting tools and many other industrial purposes.

I have found that the alloy disclosed herein cannot be economically forged or rolled, as it is particularly resistant to deformation at both normal and elevated temperatures. I have also found that it is difficult or impossible to produce commercially satisfactory shapes or forms of the alloy by means of ordinary gravity casting. I have discovered, however, that cast forms possessing valuable physical properties can be produced by casting the alloy under pressure and especially by means of centrifugal casting. By means of the latter method the grain size and density of the alloy can be closely controlled through the regulation of certain conditions of the casting operation.

I have found through experiment that by alloying or otherwise intimately combining boron, metal from the group zirconium and titanium, metal from the group tungsten, molybdenum and uranium, chromium, iron and cobalt within the range of boron 0.25% to 5%, metal from the group zirconium and titanium 0.25% to 7%, metal from the group tungsten, molybdenum and uranium 5% to 30%, chromium 1% to 25%, iron 5% to 40%, and cobalt substantially the balance that I obtain metallic compositions which possess a combination of physical properties and characteristics rendering the compositions useful for metal cutting tools, metal forming dies, working parts of internal combustion motors and many other purposes. One distinctive and advantageous characteristic of the present composition is that it is well adapted for the manufacture of cast forms by means of centrifugal casting. Another advantage is that such cast forms are readily amenable to thermal treatment for the improvement and control of important physical properties.

I have found that when the present composition is cast by any of the usual gravity casting methods that the castings do not have the proper density to render the forms commercially satisfactory. I have also found that in general the physical structure of the castings produced by gravity methods is such as to make alloys more or less unsuitable for metal cutting tools and many other applications. I have discovered that by applying suitable pressure to the molten metal while it is in the mold that cast forms can be produced having a relatively high density and the requisite physical structure. I have found that while various methods may be used for developing the desired degree of pressure on the molten metal that centrifugal casting offers a satisfactory and economical means of manufacturing cast forms of the present composition.

Cast bodies of the alloy produced by centrifugal casting may be utilized in the as cast condition. However, I usually prefer to subject the castings to a suitable thermal treatment before using them for metal cutting tools and many other purposes.

I have found by research that the preferred structure of an aggregate of the present composition comprises at least two principal constituents: (*a*) A relatively hard intermetallic compound of boron with one or more of the essential components; and (*b*) a solid solution of two or more of the essential components, which has a lower degree of hardness and functions as a matrix. For many uses an appreciable percentage of the intermetallic boron compound should be in the form of more or less finely divided particles dispersed throughout the matrix. An aggregate having the preferred physical structure possesses a combination of essential physical properties superior to the properties of a cast aggregate which has not been subjected to thermal treatment.

The present alloy is characterized by being amenable to thermal treatment for the development of precipitation hardening. As an illustration, one satisfactory method is to heat a cast aggregate of the alloy at a temperature exceeding approximately 1000° C. for a period of time sufficient to effect dissolution of a substantial portion of the boron containing segregate in the

matrix metal. In general, it is not essential that the entire aggregate be converted into a solid solution. The alloy is quenched or cooled from the primary heating temperature in such a manner as to retain substantially all of the solid solution formed during the primary heating. The hardness of the composition will then be materially lower than that of the original casting. In this condition the material may be ground, shaped or otherwise worked as may be desired. The body of the alloy can subsequently be heated at a temperature some 300° to 500° C. lower than the temperature of the primary heating. Such secondary heating will result in the precipitation of finely divided boron containing constituents from the solid solution, and an increase in hardness.

By regulating the temperature and time of the secondary heating, the ratio of precipitated boron containing constituents to the matrix metal or to other constituents of the aggregate can be accurately regulated. It will be understood that this ratio largely determines the degree of hardness, impact strength and certain other physical properties. Consequently, predetermined values of important physical properties can be accurately developed in the alloy of the present invention by means of thermal treatment.

A distinctive characteristic of a body of the alloy which has been subjected to suitable thermal treatment is the combination of relatively high hardness, e. g. 63 to 70 Rockwell C, and high resistance to impact. Another important property is that virtually all of the degrees of hardness and resistance to impact developed by thermal treatment are retained when the alloy is subjected to temperatures up to approximately 600° C.

Although I usually prefer to have the alloy composed substantially of boron, zirconium, tungsten, chromium, iron and cobalt within the percentages specified herein, I have found that the tungsten can be supplanted in whole or in part by molybdenum, uranium or both.

I have also found that in this alloy the effect of zirconium and titanium are the same so far as I have been able to observe, and consequently, either of these elements may be used to supplant the other in whole or in part.

Specific examples of the compositions within the scope of the present invention which I have found valuable for numerous industrial purposes are the following: Boron 1.20%, titanium 0.65%, tungsten, 14%, chromium 5%, iron 20%, cobalt substantially the balance; boron 1.65%, zirconium 1.30%, tungsten 19%, chromium 4%, iron 15%, cobalt substantially the balance; boron 1.80%, titanium 0.75%, molybdenum 14%, chromium 7%, iron 27%, cobalt substantially the balance; boron 1.10%, titanium 0.35%, tungsten 5%, molybdenum 12%, chromium 6%, iron 22%, cobalt substantially the balance.

I prefer to have the alloys of the present invention substantially free from carbon in order to avoid all of the disadvantages associated with alloys or compositions containing appreciable amounts of carbon, particularly when such alloys are used for metal cutting tools. I have found, however, that certain of the metals and alloys used in producing the compositions of the present invention generally contain varying amounts of carbon as an impurity and, consequently, the alloys of the present invention will usually contain small amounts of carbon in the nature of an impurity incidental to manufacture. It is essential to restrict the amount of carbon so present to amounts which will not be adversely effective on the physical properties. I have found that amounts of carbon in excess of approximately 0.30% apparently act to embrittle the alloy and also to inhibit the desired and necessary physical reactions during thermal treatment.

I have also found that materials used in producing this alloy frequently contain other elements more or less in the nature of impurities, such, for example, as manganese, silicon and aluminium. Consequently, the alloys of my invention may contain insignificant amounts of elements other than carbon in the nature of incidental impurities. In all cases, the amounts of such impurities should be restricted to percentages which will not adversely affect the properties of the alloy.

It will be evident, therefore, that the composition of the present invention comprises the following essential components: Boron 0.25% to 5%, metal selected from the group zirconium and titanium 0.25% to 7%, metal selected from the group tungsten, molybdenum and uranium 5% to 30%, chromium 1% to 25%, iron 5% to 40%, and the balance substantially cobalt.

I claim:

1. As a new article of manufacture, a centrifugally cast form of an alloy comprising metal selected from the group consisting of tungsten, molybdenum and uranium 5% to 30%, boron 0.25% to 5%, metal selected from the group consisting of zirconium and titanium 0.25% to 7%, chromium 1% to 25%, iron 5% to 40% and the balance cobalt except for minor amounts of incidental impurities in which carbon does not exceed approximately 0.30%; said cast form being characterized by a relatively fine and uniform grain structure, and being further characterized by being responsive to thermal treatment for precipitation hardening.

2. As a new article of manufacture, a centrifugally cast form of an alloy comprising metal selected from the group tungsten, molybdenum and uranium 5% to 30%, boron 0.25% to 5%, zirconium 0.25% to 7%, chromium 1% to 25%, iron 5% to 40% and the balance cobalt except for minor amounts of incidental impurities in which carbon does not exceed approximately 0.30%; said cast form being characterized by a relatively fine and uniform grain structure, and being further characterized by being responsive to thermal treatment for precipitation hardening.

3. As a new article of manufacture, a centrifugally cast form of an alloy comprising tungsten 5% to 30%, boron 0.25% to 5%, zirconium 0.25% to 7%, chromium 1% to 25%, iron 5% to 40% and the balance cobalt except for minor amounts of incidental impurities in which carbon does not exceed approximately 0.30%; said cast form being characterized by a relatively fine and uniform grain structure, and being further characterized by being responsive to thermal treatment for precipitation hardening.

4. As a new article of manufacture, a centrifugally cast form of an alloy comprising molybdenum 5% to 30%, boron 0.25% to 5%, zirconium 0.25% to 7%, chromium 1% to 25%, iron 5% to 40% and the balance cobalt except for minor incidental impurities in which carbon does not exceed approximately 0.30%; said cast form being characterized by a relatively fine and uniform grain structure, and being further characterized by being responsive to thermal treatment for precipitation hardening.

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