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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 boron, tungsten, chromium and cobalt, which is characterized by being responsive to thermal treatment for the improvement of physical properties.

An object of the present invention is to provide an alloy especially adapted for use as metal cutting tools, the cutting efficiency of which is superior to that of present known high speed steels and other alloys. A further object is to provide an alloy which is free from, or substantially free from carbon and which is readily amenable to thermal treatment, by means of which the hardness, tensile strength, cutting efficiency and other physical properties and characteristics may be accurately controlled over a comparatively wide range.

I have found through experiment that by alloying or otherwise intimately combining boron, tungsten, chromium and cobalt within the range of boron 0.50% to 2.75%, tungsten 5% to 25%, chromium 1% to 15%, and cobalt substantially the balance, that I obtain metallic compositions which possess in combination materially improved physical properties compared to those of heretofore known alloys or compositions intended for the cutting or working of metals.

Alloys of this invention may be used in the cast condition but approximate maximum values of hardness, resistance to impact and certain other important physical properties can be developed only through thermal treatment, or through mechanical working and subsequent thermal treatment. Bodies of the alloys which have been subjected to such treatment are particularly valuable for use as tools, dies and the like for the cutting or mechanical working of metals.

Numerous metallic compositions have heretofore been proposed as improvement on the generally known 18—4—1 type of tungsten-chromium-vanadium high speed tool steel, and while many of such compositions possess greater hardness than such steel, all of them have disadvantages which render them unsuitable for general application as metal cutting or forming tools. Compositions containing principally carbides of tungsten, molybdenum or tantalum bonded with a relatively soft matrix metal have a high degree of hardness, but are extremely brittle. Cast compositions of the types heretofore proposed require the presence of at least 1.50% carbon to qualify as metal cutting tools and, as is well known, such alloys are not only brittle, but are so sensitive to various operating conditions as to greatly restrict the scope of usefulness. One of the greatest disadvantages of such heretofore proposed compositions is that none of them are responsive to thermal treatment for regulation of physical properties, and consequently physical properties and characteristics are governed entirely by the chemical composition of the sintered or cast material.

My alloy may be used in the as-cast condition, or it may be forged or otherwise mechanically worked. I have found that both the cast and forged material are amenable to thermal treatment. For example, cast bodies of this alloy may have a hardness of from 50 to 60 on the Rockwell C. scale and by subjecting the material to suitable thermal treatment, such as quenching from a temperature higher than approximately 1000° C., the hardness may be lowered to an approximate range of from 40 to 47 Rockwell C. In this condition the bodies may be ground, shaped or formed, as desired. The alloy may subsequently be submitted to a second thermal treatment, such as heating to a temperature of less than 1000° C. for a period of one hour or more, by which the hardness may be increased to from approximately 60 to 70 Rockwell C. In the latter condition the alloy is especially valuable for the cutting or mechanical working of a large number of metals and alloys, as well as numerous non-metallic materials. An important property of this alloy is that virtually all of the maximum hardness, developed by thermal treatment, is retained when the alloy is subjected to elevated temperatures, e. g. such as are generated in the tip of a tool cutting metal at high speed. Although the alloy has a high degree of hardness and resistance to abrasion by hot metal chips, especially after thermal treatment, it is remarkably resistant to failure from sudden or repeated shock. Therefore, tools made of the present alloy retain an efficient cutting edge for longer periods than other tools.

The more important distinctive and valuable advantages are, apparently, due to the presence of appreciable amounts of boron in the composition, in conjunction with the other essential component elements within the percentages specified herein.

I have found that molybdenum may be used to supplant all or a portion of the tungsten of the present alloy. Likewise, uranium may be used in place of either tungsten or molybdenum.

Specific examples of compositions within the scope of the present invention which I have found

well adapted for metal cutting tools, dies and the like are the following: boron 1.20%, tungsten 14%, chromium 5%, cobalt balance; boron 2.10%, tungsten 19.50%, chromium 4%, cobalt balance; boron 1.65%, molybdenum 13%, chromium 3.5%, cobalt balance; boron 1.70%, tungsten 5%, molybdenum 10%, chromium 8%, cobalt balance.

An objective of the present invention is to provide alloys having high hardness, high resistance to shock and impact, advantageous metal cutting properties, etc., which are free or substantially free from carbon, and thus eliminate all of the serious disadvantages associated with carbon containing non-ferrous alloys or compositions intended for metal cutting, tools. Although I prefer to have the alloys of this invention entirely free from carbon, in many instances I have found carbon present in the nature of an impurity incidental to manufacture. It is important to restrict the amount of carbon so present to a maximum of about 0.15%, as I have found that the presence of higher percentages of this element make the alloy extremely brittle and subject to failure during cutting operations, and, also inhibits the desired and necessary reactions during thermal treatment. Furthermore, the presence of appreciable amounts of carbon decreases the red hardness of the alloy, i. e. hardness at temperatures of approximately 550° C. and higher.

By reason of the fact that the elements forming the essential components of the alloy of the present invention invariably are contaminated with other elements when produced in commercial quantities, the alloys of my invention usually contain insignificant amounts of one or more elements in the nature of impurities incidental to manufacture. The amount of such impurities should be restricted to percentages which are not effective on the physical properties or characteristics of the alloy, nor on the physical reactions during thermal treatment. I have found that the amount of any one of such incidental impurities should be restricted to percentages not exceeding 1%, and in many instances to materially lower percentages. The presence of larger amounts of such impurities, particularly silicon and aluminum, materially decreases the resistance of the alloy to failure under shock and impact during cutting operations, and, further, inhibits the desired physical reactions during thermal treatment. Therefore, the presence of effective amounts of impurities, such as carbon, silicon and aluminum, acts to appreciably lower the cutting efficiency and general value of the present alloy.

My investigations indicate that the preferred structure of a body of the present alloy, particularly after thermal treatment, comprises at least two principal constituents: one, a relatively hard intermetallic compound of boron with one or more of the other essential components; and, second, a solid solution of two or more of the essential components which has a lower degree of hardness and functions as a matrix. In some instances the structure will contain a third constituent in the nature of an eutectoid. The ratio of the constituents and the ratio of particle size in any particular body of the alloy may be accurately controlled and fixed over a wide range by means of thermal treatment, or mechanical working and subsequent thermal treatment.

By reason of the combined advantageous physical properties possessed by the alloy of the present invention, tools and other articles composed of this alloy may be operated efficiently and economically under conditions which are impossible or uneconomical with tools or articles composed of heretofore known alloys or metallic compositions.

By the term "the balance substantially cobalt" in the foregoing and in the following claims, I intend that the alloy of the present invention comprises boron, chromium, and metal of the group tungsten, molybdenum and uranium within the percentage limits specified, with the remainder cobalt except for ineffective amounts of impurities which may be present incidental to manufacture.

I claim:

1. An age hardened alloy containing boron 0.50% to 2.75%, metal from the group tungsten, molybdenum and uranium 5% to 25%, chromium 1% to 15%, the balance substantially cobalt.

2. An age hardened alloy containing boron 0.50% to 2.75%, tungsten 5% to 25%, chromium 1% to 15%, the balance substantially cobalt.

3. An age hardened alloy containing boron 0.50% to 2.75%, molybdenum 5% to 25%, chromium 1% to 15%, the balance substantially cobalt.

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