

UNITED STATES PATENT OFFICE.

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ALLOY AND PROCESS FOR MAKING SAME.

No Drawing.

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Our invention relates to alloys for use as high-speed cutting tools and the like which are similar in general physical properties and structural characteristics to those obtained by H. S. Cooper, U. S. Patents Nos. 1,221,769, 1,277,046, 1,278,304, 1,350,359, and 1,461,178.

Our new alloys contain as essential components nickel or cobalt in preponderating proportion, usually substantial amounts of tungsten, small amounts of boron up to about 1%, and preferably substantial amounts of zirconium. Minor amounts of silicon and aluminum are usually present and have more or less effect on the properties of the alloy. Molybdenum or uranium may be present, replacing part or all of the tungsten.

Our invention also includes the preparation of an alloy in which substantial amounts of titanium are substituted for zirconium or used with the same.

Our invention also covers a new and useful process of preparing alloys of this class.

Heretofore in preparing alloys such as those disclosed by Cooper in the patents above mentioned, the desired hardness has been obtained by adding a considerable amount of aluminum over and above that contained in the alloys used as raw materials. A great deal of trouble was encountered through oxidation of this excess aluminum and in addition the tungsten segregated very rapidly as soon as the aluminum was added. We have now produced alloys of this type in which hardness and good cutting properties are secured by raising the zirconium content and correspondingly decreasing the aluminum content, whereby oxidation of aluminum and the segregation of tungsten are largely avoided.

We have found that the hardness of the alloy is increased by the presence of boron therein, and that there is a marked refinement of grain. We have also found that the boron seems to act in conjunction with the zirconium in producing a much better cutting tool than can be made from alloys of this type which do not contain boron.

One class of alloys made in accordance with our invention contain 5 to 12% tungsten, 6 to 12% zirconium, 3.5 to 6% silicon, 3 to 5% aluminum, up to 1% boron, the balance being principally nickel. The boron may be added in the form of ferro-boron, chromium-boron, boron carbide or any other

suitable alloy of boron. When ferro-boron or chromium-boron are used, small amounts of iron or chromium will be introduced into the final alloy, but these have no appreciable effect on its properties. The other raw materials frequently contain small amounts of iron so that the iron content of the final alloy may be as high as 2 or 3%.

These alloys may be conveniently made by melting the nickel-, tungsten-, silicon-, and boron-containing materials together in a graphite crucible in any suitable type of furnace, raising the temperature of the molten bath to 1600°-1800° C., and then stirring the zirconium in the form of some suitable zirconium alloy into the melt. The zirconium alloy will dissolve quite readily if vigorous stirring is employed. The melt may be poured at once into molds, (sand, carbon or graphite) but a cleaner metal will result if the melt is left in the furnace and heated for fifteen or twenty minutes more. A coating of oxide will be formed over the surface of the metal during this second heating and this coating will have to be broken through before the melt can be poured, but the metal is very fluid and runs readily as soon as the crust is broken.

A commercial alloy of zirconium and nickel has been found to give satisfactory results as the source of the zirconium in this alloy. It is friable and may be readily crushed to a powder. The best results have been obtained when the nickel zirconium alloy was used in the form of approximately 40 mesh powder. The nickel zirconium alloy contains approximately 37% nickel, 34% zirconium, 12 to 15% aluminum and 10 to 12% silicon. When such a nickel zirconium alloy is used, it may supply the entire quantity of aluminum entering the alloy. It has been found that with a zirconium content of 8 to 10% in the final alloy, the aluminum should be between 3% and 4% in order that the alloy may have a hardness suitable for use as a cutting tool. One heat of this alloy which had the proper hardness and which gave good results when used as a cutting tool had the following composition: tungsten, 7.67%, aluminum, 3.62%, silicon 4.19%, iron 1.51%, boron .63%, zirconium, 7.21%, nickel remainder.

Another class of alloys prepared in accordance with our invention and possessing physical properties and structural characteristics

similar to those of the alloys above described is characterized by the use of substantial amounts of titanium in lieu of zirconium. These alloys, the preferred composition range of which is 5 to 12% tungsten, 6 to 12% titanium, 3.5 to 6% silicon, 3 to 5% aluminum, up to 1% boron, with the balance principally nickel, are prepared by melting nickel-, tungsten-, silicon-, and boron-containing materials together in a graphite crucible in any suitable type of furnace, and when the molten bath has been heated to a temperature of 1600° to 1800° C., stirring the titanium in the form of a titanium alloy into the melt. The titanium alloy will dissolve quite readily if vigorous stirring is employed and the melt may be poured at once into sand, carbon, or graphite molds. A titanium alloy which has given good results in this work contains 64.8% titanium, 27.3% aluminum, 2.2% silicon, 2.1% iron and 1.0% carbon. It is friable and may be crushed to a powder. The best results have been obtained when it was crushed to approximately 40 mesh. No aluminum except that contained in the titanium alloy is added to the melt. One melt of this cutting tool alloy which had the proper hardness and good cutting quality had the following composition: tungsten 7.23%, titanium 7.20%, aluminum 3.90%, silicon 4.40%, iron 0.95%, carbon 0.52%, boron 0.55%, nickel remainder.

The titanium-containing alloy herein described constitutes the subject matter of a separate application Serial No. 92,584, filed March 5, 1926.

Nickel-aluminum-silicon alloys have also been prepared having compositions such as are disclosed by Cooper in U. S. Patent No. 1,461,178, but with the addition of boron in small amounts up to 1%. Such alloys have shown a marked increase in strength, hardness and cutting qualities when used as cutting tools. Such alloys containing boron are also characterized by marked refinement of grain structure.

While in the examples above given nickel has been specified as the principal constituent of the alloy, it is to be understood that cobalt may be substituted for nickel or used with the same, and that "nickel" is used in the claims to mean either nickel or cobalt or both.

All the alloys comprised within the invention are suitable for tools for the high-speed cutting of cast iron, steel and semi-steel, though they are also useful for other purposes. The term "high-speed" is here used in the same sense as in the common expression "high-speed steel", and imports conditions of such severity that ordinary carbon

steels subjected to them would be softened by the heat generated in the cutting and thus become useless.

We claim:—

1. An alloy containing from 3 to 5% aluminum, 3.5 to 6% silicon, 5 to 12% tungsten, 6 to 12% zirconium, boron in substantial and effective amounts up to 1%, the balance being principally nickel.

2. A cutting tool composed of an alloy containing from 3 to 5% aluminum, 3.5 to 6% silicon, 5 to 12% tungsten, 6 to 12% zirconium, boron in substantial and effective amounts up to 1%, the balance being principally nickel.

3. The process of combining a metal having the alloying properties of zirconium with nickel, tungsten and silicon, which consists in melting nickel, tungsten and silicon together, heating the bath to between 1600° and 1800° C., and then introducing a material containing said metal into the melt while maintaining the aluminum content of the bath below the point at which pronounced segregation of tungsten takes place.

4. The process of preparing an alloy containing nickel in preponderating amount, silicon, aluminum, from 5 to 12% of tungsten and from 6 to 12% zirconium, comprising melting nickel, tungsten and silicon together, introducing a zirconium containing alloy into the melt, while maintaining the aluminum content of the both below the point at which pronounced segregation of tungsten takes place.

5. A non-ferrous alloy suitable for tools for the high-speed cutting of cast iron comprising a preponderating amount of nickel, 3% to 5% of aluminum, 3.5% to 6% of silicon, 5% to 12% of tungsten, and boron in substantial and effective amounts up to 1%.

6. A non-ferrous alloy suitable for tools for the high-speed cutting of cast iron which contains 3% to 5% of aluminum, 3.5% to 6% of silicon, 5% to 12% of tungsten, 6% to 12% of zirconium, and approximately 0.6% of boron, with the balance principally nickel.

7. A non-ferrous alloy suitable for tools for the high-speed cutting of cast iron which contains from 3% to 5% of aluminum, 3.5% to 6% of silicon, 5 to 12% of tungsten, 6% to 12% of zirconium and titanium taken together, and boron in substantial and effective amounts up to 1%, with the balance principally nickel.

In testimony whereof, we affix our signatures.

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