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HARD METAL TOOL ALLOY AND METHOD
OF PRODUCING THE SAME

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This invention refers to a hard metal tool alloy and method of producing the same.

This invention forms a continuation in part of my copending patent applications Ser. No. 164,166, filed September 16, 1937; and Ser. No. 727,781, filed May 26, 1934; and Ser. No. 743,717, filed September 12, 1934, issued into Patent 2,122,157; which were in turn continuations in part of my then pending patent application Ser. No. 625,042, filed July 27, 1932, issued into Patent 2,091,017; which was in turn then copending with my patent applications, Ser. No. 656,103, filed February 10, 1933, and issued into Patent 1,959,879; and Ser. No. 452,132, filed May 13, 1930.

It is an object of the invention to increase the hardness of such hard metal tool alloys without impairing their toughness.

It is another object of the invention to increase the resistance of such hard metal tool alloys against mechanical wear and chemical effects such as of the oxygen of the surrounding air, or moisture, or a cooling liquid such as water.

It is still another object of the invention to increase the efficiency of hard alloys of this kind in cutting, drilling, milling, and machining steel.

This and other objects of the invention will be more clearly understood when the specification proceeds.

Hard metal tool alloys of the type referred to have been made of tungsten carbide and auxiliary metal taken substantially from the iron group, in amounts from about 3% to 20%. The tungsten carbide has been finely powdered and mixed with the auxiliary metal, and the mixture heated to sintering temperature. Such hard metal tool alloys could be utilized for machining cast iron but do not prove efficient in machining steel.

In contradistinction hereto the invention no longer uses carbide of a single element, viz. tungsten, but of two elements, viz. tungsten and titanium, compounded to form substantial amounts of homogeneous carbide crystal structures or solid solutions of approximately greatest hardness.

A homogeneous crystal structure or solid solution, sometimes also termed mixed crystal, of two metals generally exhibits a greater hardness than the solvent metal. Plotting in a graph the hardness of the solid solution against the concentration of the component metal, it generally appears that the hardness increases with the concentration to a flat maximum of the hardness-composition curve and includes in that flat maximum the equi-atomic ratio of the component metals (Jeffries and Archer, "The Science of Metals," 1924, pgs. 254 ff.; M. v. Schwarz "Metall- und

Legierungskunde," sec. ed., 1929, pg. 49). By analogy, according to the invention, approximately greatest hardness of the homogeneous carbide crystal structures or solid solutions formed of tungsten carbide (WC) and titanium carbide (TiC) is obtained close to, within an approximation of about 10% (within which range the term "approximate ratio" used in the appended claims should be understood), and at their equi-molecular ratio, the latter corresponding to one atom tungsten, one atom titanium and two atoms carbon and to the atomic formula $WTiC_2$. Calculating this exact ratio, the hardest homogeneous carbide crystal structure is to result from 60 parts TiC by weight and 196 parts WC and to contain about 18.8% by weight titanium, 71.8% tungsten and 9.4% carbon.

Any suitable method may be used for the production of that hard composition. Thus for instance titanium carbide and tungsten carbide can be intimately admixed in the approximate ratio stated, converted by heat treatment substantially into solid solutions and cemented with auxiliary metal. It is also possible to mix oxides of tungsten and titanium in finely or very finely divided form, with an addition of suitably pulverized solid carbon, and to heat them to a suitable extent in an electric furnace whereby substantially homogeneous tungsten-titanium-carbon crystal structures are obtained. Preferred temperatures to which the mixture of metallic tungsten and titanium, or tungsten oxide and titanium oxide, admixed with sufficient carbon in very finely divided form should be heated in order to yield carbide and homogeneous carbide crystal structures of the kind defined above, are ranging from about 1600° C. to about 2000° C. or even higher, up to about 2600° C. The temperature depends upon the duration of heating, which should be from about one to four hours. Some part of the auxiliary metal such as nickel and/or cobalt may be added before heating; this metal melts below 1500° C.

In such a way a carbide substance is obtained which in hardness is superior to tungsten carbide and titanium carbide alone and resists higher temperatures in oxidizing atmosphere than tungsten carbide does.

An electric furnace can be used for heating, particularly sintering or fusing the initial mixture. Heating can be effected also by means of high frequency induction, if desired in vacuo.

With the tungsten-titanium-carbon-product prepared in the above described way, cementing metallic additions are admixed which increase

the toughness of the final alloy. Such additions consist essentially of nickel, iron, cobalt, separately or in suitable mixture and in total amounts from about 3% to 25% by weight.

Carbides of substances other than tungsten and titanium can likewise be added, for instance carbides of boron, vanadium or molybdenum.

Thus the metals tungsten and titanium, or their oxides may be mixed with carbon in the approximate ratio stated and heated up to about 1600° C. or to sintering or fusing temperatures, the product so obtained comminuted and in powdery form admixed with auxiliary metal of the kind and in the amount mentioned above. Powdery carbides of the other elements previously referred to may be admixed as additions only. The finely divided and intimate mixture thus obtained may then be pressed to shape and sintered into a dense and tough body.

The homogeneous tungsten-titanium-carbon crystal structures can also be produced combined with auxiliary metal in the amounts and of the nature stated and, if desired, also combined with one or more carbides of boron, vanadium or molybdenum, whereby in a single process a body is obtained which possesses the desired hardness as well as toughness.

Thus a finely divided intimate mixture can be prepared from the metals, or metal oxides, or carbides which are to be contained in the final hard alloy, i. e. of tungsten, titanium and if other carbide additions are to be present, boron, vanadium, and/or molybdenum, and of carbon necessary to carburize the metals or oxides if employed, as well as of auxiliary metal essentially selected from nickel and cobalt in amounts from about 3% to 22%, the mixture pressed to shape and heated to sintering temperature until a cemented tough and hard body and substantial amounts of homogeneous carbide crystal structures composed of titanium, tungsten and carbon atoms in the approximate ratio previously stated, are obtained.

The auxiliary metal referred to above in the various methods of manufacture described may in particular consist of 3% up to 9% to 13% of nickel and/or cobalt to which chromium up to about 1% may be added.

In sintering the molded powdery mixture into a final cemented product, temperatures of about 1330° C. up to about 1400° C. and 1600° C. are to be applied if essentially auxiliary metal of the iron group is used with melts substantially within that temperature range.

The amount of carbides admixed as additions should preferably be about 1% to 30%.

The cemented hard material thus obtained is of high resistivity against oxidation. A desirably small size of crystals is obtained and maintained. The end-product will contain as essential constituents and in total amounts preferably between 35% and 95% homogeneous carbide crystal structures composed of tungsten, titanium and carbon, the titanium and tungsten present approximately in mono-atomic ratio, i. e. a ratio corresponding to one atom of tungsten and one atom of titanium, to which a total of two atoms of carbon is added. Hence the relative amount of the components will be about 18.8% by weight of titanium, about 71.8% of tungsten and about 9.4% of carbon. The matrix by which this hard composition is cemented consists of auxiliary metal, and it may also contain free carbide of tungsten or titanium and additions of other carbide, or carbides as above out-

lined. Molded or shaped alloys prepared according to the above are, as a rule, not used for the production of the entire tool but merely for such parts of the tool which are actually used for cutting, drilling, etc., such parts being subject to wear.

What I claim is:

1. A cemented hard metal composition sintered by heat treatment, for tool elements and other working appliances, consisting substantially of auxiliary metal essentially of the iron group in amounts of about 3% to 22%, of about 58% to 76% tungsten carbide and about 16% to 25% titanium carbide, said carbides present in approximately mono-molecular ratio, an approximation of 10% as a minimum, and forming solid solutions by heat treatment in substantial amount.

2. A cemented tough hard metal composition, for tool elements and other working appliances, consisting substantially of a cementing metal matrix selected from the group consisting of cobalt and nickel and constituting about 3% to 22% of the composition, and of finely divided hard particles forming the balance of the composition, said particles consisting of carbide crystal structures of tungsten and titanium and including in substantial amount homogeneous carbide crystal structures composed of the elements tungsten, titanium and carbon in the approximate ratio of one atom tungsten, one atom titanium and two atoms carbon, said homogeneous carbide crystal structures obtained from said elements by heat treatment at temperatures ranging between about 1600° and about 2600° C.

3. A cemented tough hard metal composition, for tool elements and other working appliances, consisting substantially of a cementing metal matrix selected from the group consisting of cobalt and nickel and constituting about 3% to 22% of the composition, and of finely divided hard particles consisting of homogeneous carbide crystal structures composed of the elements tungsten, titanium and carbon in the approximate ratio of one atom tungsten, one atom titanium and two atoms carbon, said structures obtained from said elements by heat treatment at temperatures ranging between and including sintering and fusing temperatures of the component metals.

4. A cemented tough hard metal composition, for tool elements and other working appliances, consisting substantially of a cementing metal matrix selected from the group consisting of cobalt and nickel and constituting about 3% to 22% of the composition, and of finely divided hard particles consisting of homogeneous carbide crystal structures composed of the elements tungsten, titanium and carbon and obtained by heat treatment of said elements at temperatures ranging between and including sintering and fusing temperatures of the component metals, said component metals and carbon present in said structures approximately in the following amounts by weight: 71.8% tungsten, 18.8% titanium and 9.4% carbon.

5. A hard composition of matter substantially comprising hard homogeneous carbide crystal structures composed of the elements tungsten, titanium and carbon cemented in a metal matrix selected from the group consisting of cobalt and nickel and constituting about 3% to 25% of the composition, the atomic ratio of said elements in said structures corresponding to the atomic formula $WTiC_2$.

6. In a process of producing a hard composition, the steps of admixing about 3% to 22% metal selected from the group consisting of nickel and cobalt with tungsten, titanium and carbon in the approximate ratio of 71.8% by weight tungsten, 18.8% titanium and 9.4% carbon, and heating said mixture to a temperature high enough to melt at least said metal selected from said group and to make said tungsten, titanium and carbon react upon each other so as to form homogeneous carbide crystal structures composed of said tungsten, titanium and carbon in said approximate ratio while said metal of said group upon solidification forms a matrix.

7. In a process of manufacturing a hard com-

position, the steps of admixing about 3% to 22% of metal selected from the group consisting of nickel and cobalt with tungsten oxide, titanium oxide and carbon in a ratio that upon reacting of said carbon with said oxides approximately 71.8% by weight tungsten, 18.8% titanium and 9.4% carbon result, and heating said mixture to a temperature high enough to melt at least said metal of said group and to make said carbon react upon said oxides so that homogeneous carbide crystal structures result composed of said tungsten, titanium and carbon in said approximate ratio and said metal of said group forms a matrix.

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