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HARD ALLOYS

Clarence W. Balke, Highland Park, Ill., assignor
to Ramet Corporation of America, North Chi-
cago, Ill., a corporation of Illinois

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This invention relates in general to hard alloys, and has more particular reference to an alloy of tantalum carbide, molybdenum and nickel.

5 The invention includes among its objects the provision of a hard and tough alloy suitable for use in the fabrication of metal working tools consisting substantially entirely of tantalum carbide, but including in addition thereto molybdenum and nickel making up together not more
10 than 25% of the alloy, and the provision of such an alloy which has an actual density greater than the mean or average density of its constituents, and which, when in the form of metal
15 working tools, is durable and does not require frequent regrinding.

My invention includes among its other objects, so combining molybdenum and nickel with tantalum carbide making up not more than 90%
20 of the entire alloy, that the resulting material is substantially imporous at a magnification of 1500 diameters.

Other objects and advantages of the invention will be apparent from the following description.

25 In order to accomplish the foregoing objects, I prefer to make the tantalum carbide by heating a mixture of finely divided tantalum and carbon in hydrogen or in vacuo, to about 2000° C. in order to form tantalum carbide according to
30 the formula TaC, having substantially 6.2% carbon, and in order to prevent embrittling gases or substances such, for example, as oxygen, from contaminating the carbide.

This tantalum carbide is then reduced to a
35 finely divided form and finely divided molybdenum in the desired proportions is admixed therewith. To this mixture of tantalum carbide and molybdenum, such an amount of nickel is added that the total molybdenum nickel content
40 will not exceed 25% by weight of the entire alloy, the percentage by weight of nickel being greater than the percentage by weight of molybdenum. This mixture is brought to a desired size and shape and subsequently heat treated in vacuo.
45 The nickel is preferably added by grinding the other constituents by means of nickel grinders in the presence of a low boiling point hydrocarbon, such as naphtha, which may be subsequently volatilized out by heat in order to prevent contamination by embrittling gases.
50

For the best results, the heat treatment in vacuo of the mixed powders which have previously been formed as by pressing to a desired size and shape, should be carefully carried out
55 in order to produce a material which upon cool-

ing will have a greater density than the mean or average density of the tantalum carbide, molybdenum and the nickel. Of course, the exact temperature to which the pressed powders will be heated may vary slightly in accordance
5 with the formula being employed in the formation of the alloy. I have found, however, that the temperature should not exceed that minimum temperature at which maximum shrinkage of the powdered mixture occurs. This tempera-
10 ture may readily be determined by trial or experiment for any proportion of constituents. For example, I have found that for a mixture of substantially 80% by weight of tantalum carbide
15 powder, 9% by weight of molybdenum powder, and 11% by weight of nickel powder, the final heat treating step in vacuo should not exceed 1400° C. and preferably should be about 1380° C.

In so heating the pressed powders in vacuo, the relatively great shrinkage of the pressed mixture apparently takes place substantially entirely
20 during a relatively small change in temperature near the final or desired temperature. It is important that this shrinkage occurs or takes place gradually if the maximum benefits of this inven-
25 tion are to be attained. Accordingly, I bring the pressed powders up to a temperature of about 1100° C. and thereafter slowly increase this temperature during from about one and one-half to
30 about two hours to the final temperature of about 1380° C. whereby to control for the most part, the relatively great shrinkage of the pressed powders.

This novel alloy of mine at a magnification of 1500 diameters is substantially free of porosity
35 and has a material or an alloy which resembles in the microphotographs, crystallites intermittently but uniformly dispersed throughout a substantial aphanitic structure or phase, or at least a
40 phase that has such exceedingly fine grains that they are undiscernible. This intermittent material is rich in nickel and probably includes some or all of the molybdenum and some of the tantalum carbide which may be dissolved in the nickel-
45 rich alloy.

My novel alloy is remarkably hard, strong, and tough, the Rockwell A hardness with a 60 kilogram load on the C scale ranging between 87 and 91. The Brinell strength of a piece of my alloy
50 $\frac{3}{8}$ inch by $\frac{1}{2}$ inch, measured between supports $\frac{1}{8}$ inch apart is between 2300 and 2600.

My alloy is substantially inert chemically to substances or compounds which are commonly used as coolants, such as lactic acid. In fact,
55 chemicals which ordinarily attack some of the

constituents, such as nitric acid and sodium hydroxide, seem to have very little or no effect upon my alloy.

Thus an alloy having the desirable properties of great hardness and strength, durability and chemical inertness, is provided and may be readily fabricated as working portions which may readily be attached to body or shank portions to provide tools that resist cratering and do not require frequent regrinding or replacement.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent of the United States is:

1. A method of making a tool alloy having a greater actual density than the average density of its constituents, which comprises heating a mixture including tantalum carbide, nickel, and molybdenum powders to a temperature at which appreciable shrinkage begins in vacuo, and thereafter slowly raising the temperature of said mixture in vacuo to 1380° C., whereby to control the shrinkage of the mixture.

2. A method of making a tantalum carbide alloy including up to 25% by weight of nickel and molybdenum, which comprises heating the mixture in vacuo to about 1100° C. and slowly raising the temperature of said mixture in vacuo from 1100° C. to 1380° C., whereby the nickel and molybdenum are uniformly dispersed throughout the tantalum carbide.

3. A method of making an alloy imporous at a magnification of 1500 diameters, which comprises uniformly dispersing substantially 11% by weight of nickel and 9% by weight of molyb-

denum through substantially 80% by weight of tantalum carbide while heating the powders of said nickel, molybdenum and tantalum carbide in vacuo to a temperature below the melting point of any of the said constituents.

4. A sintered tantalum carbide alloy having a greater actual density than the average density of its constituents, said alloy having a substantially aphanitic phase and a nickel-rich substance, resembling crystallites, of nickel and molybdenum uniformly and intermittently dispersed throughout such phase, the nickel and molybdenum which form said nickel-rich substance together constituting less than 25% by weight of the alloy, said alloy having been produced by sintering in vacuo and being characterized by its relatively great strength and hardness with respect to an alloy produced from the same raw material by sintering in an inert atmosphere.

5. A sintered hard metal composition suitable for use as a metal working tool, such alloy consisting substantially of tantalum carbide and a nickel-rich substance, resembling crystallites, of nickel and molybdenum intermittently and uniformly formed in situ throughout the alloy, said nickel-rich substance constituting less than 25% by weight of the alloy, and said alloy having been produced by sintering in vacuo and being characterized by a greater actual density than the average density of its constituents and being further characterized by its relatively great strength and hardness with respect to an alloy produced from the same raw material by sintering in an inert atmosphere.

CLARENCE W. BALKE.