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COMPOSITION OF MATTER

Philip M. McKenna, Unity Township, Westmoreland County, Pa., assignor to Vanadium-Alloys Steel Company, Latrobe, Pa., a corporation of Pennsylvania

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The purpose of this invention is to produce a hard metal composition possessing desirable qualities of hardness, strength and inertness to chemical and physical destructive forces which adapt it to a number of useful purposes, such as for metal cutting tools, particularly steel-cutting tools and tools for cutting other ferrous alloys at high speeds on machines such as lathes, shapers, milling machines, and hole-drilling and finishing machines; also for wire drawing dies, metal forming dies, guides for spinning thread and twine, and guides which are subjected to wear as in automatic grinding machines, wear resisting bearings and pivots in such machines as the Atwood machine, electric meters, clocks, weighing scales and for services resisting pressure, heat abrasion or chemical destruction, or combination of any or all of these.

The essential elements of my composition are tantalum carbide and malleable, ductile tungsten metal, which latter I produce and maintain by a novel process hereinafter disclosed, from a molten tungsten alloy.

This enables me to produce a mechanically strong composition of tantalum carbide and tungsten using more than 71% tantalum carbide and less than 29% tungsten, possessing greater strength than a composition formed by the usual process of producing a conglomerate welded mass of tantalum carbide and tungsten as disclosed in United States Patent No. 1,848,899, granted March 8, 1932.

In the art of producing malleable tungsten it is known that alloying the tungsten with nickel makes makes the tungsten malleable as disclosed in United States Patent No. 1,110,303 to Hans Kreusler.

The molten tungsten-nickel alloys are described in the International Critical Tables, Vol. II, page 438, by a diagram showing uniform solutions of WNi_6 and various eutectics. Referring to this diagram it is seen that while an alloy of 55% tungsten and 45% nickel has a melting point as low as 1460° C., that on increasing the tungsten content the melting point mounts rapidly to temperatures above the disintegration point of crucible refractories which could be used to melt the binary alloy. Therefore, I found it impracticable to produce ductile tungsten alloys much above 55% tungsten by melting.

The improvement in strength of my hard composition, when this ductile form of tungsten is used, is marked and as low as 6% of tungsten in this form is sufficient to produce a tool strong enough to serve as a lathe tool for cutting steel, while on the other hand if the tungsten were added as grains of tungsten metal powder as reduced by hydrogen equal percentages would not suffice to form an equally durable tool with tantalum carbide.

Heretofore hard compositions of approximately 80% TaC, 10% Ni and 10% W have been manufactured by adding grains of tungsten metal powder to the composition in the ball mill. In these cases the amount of tungsten which can be added is restricted to an amount which can be absorbed by the amount of nickel used, at the temperature at which the composition is heated. At about 1400° C., the usual temperature, this is about an equal weight of tungsten to the nickel and the temperatures cannot be materially increased to dissolve a greater proportion of tungsten without vaporization of the nickel, especially as the heating is usually carried out in a vacuum furnace.

Attempts to add more tungsten as metal powder grains results in a decrease in transverse break strength of the composition due to the fact that the tungsten grains as such weaken the composition, unless the tungsten is in malleable form, as obtains when the tungsten is first dissolved and then precipitated and filtered out of the nickel by the process I hereinafter disclose.

If a greater quantity of tungsten than say 10% is put into the composition with enough nickel to absorb it, the quantity of nickel necessary being likewise increased, the effect of this surplus nickel is to soften the hard composition to a point where it is not valuable for steel cutting.

I have found it desirable and necessary to produce the powder of tantalum carbide and metal from which I make the hard composition (by subsequent heating and pressing) by abrasion of the metal under a non-oxidizing fluid. These conditions I obtain by first melting tungsten with nickel, producing ingots 55% tungsten and 45% nickel. This melting can be done conveniently in silica sand crucibles in a high frequency induction furnace such as is used for melting nickel, the temperature required being 1460° C.

I melt the nickel first, and then add pure tungsten powder, de-oxidizing the heat with a little ferro-silicon before pouring. These ingots may then be cut up into $\frac{1}{2}$ " cubes with a thin abrasive wheel. These slugs are then used as grinding balls in a ball mill, in which the tantalum carbide is ground in a non-oxidizing liquid such as benzene, or methylene dichloride, the freshly abraded surfaces of the metal particles being preserved from oxidation or gas films by being covered with the non-oxidizing fluid. The tungsten prepared in this way is especially well protected from oxidation, or the absorption of gas films, by being alloyed with the nickel.

Grinding in the ball mill is continued until the required percentage of tungsten is obtained in the powder. Using a mill $\frac{5}{8}$ " in diameter and 6" long with about 6,000 grams of nickel-tungsten slugs it required three days to add 23% of

tungsten to 200 grams of tantalum carbide, as an example. I have found that more than 11% of nickel in the hard composition softens it too much, and that 2% to 8% is more satisfactory for a hard composition to resist abrasive cutting. At the same time it is desirable to put in more than 12% tungsten to get the combination of strength and hardness desired. The problem then is presented, how to get a higher ratio of tungsten to nickel in the final composition than is obtainable in the nickel-tungsten slugs which must be melted.

This I have solved by the discovery that by adding manganese to the powder containing the abraded 55% tungsten 45% nickel alloy and the tantalum carbide, the nickel may be liquidated out in greater part leaving the tungsten concentrated and entrained in the composition in a highly desirable malleable form.

The manganese acts by alloying with the nickel, forming a very fluid liquid containing a high percentage of nickel, while the tungsten, or high percentage tungsten-alloy, is precipitated out of solution and filtered out in the finely divided tantalum carbide, through which the fluid nickel manganese alloy passes and is removed from the composition.

I add an amount of manganese from one-tenth to six-tenths of the nickel which I wish to remove. For example, I add 5% manganese to a mix containing say 13% Ni.

Thus I obtain malleable tungsten in my composition with a higher ratio of tungsten to nickel than can be obtained by adding tungsten powder and nickel to the tantalum carbide.

For example—I ground 150 grams of tantalum carbide, 6.23% carbon, with alloy slugs containing 55% tungsten, 45% nickel, with $7\frac{1}{2}$ grams of manganese metal, for two and a half days; the powder then containing 13½ per cent nickel and 16.5% tungsten. On heating 100 grams of this powder, moist with benzene, in a $1\frac{1}{8}$ " square hole in a graphite mold, fitted with a graphite plunger, above the liquefaction temperature of the manganese nickel alloy which is about 1300° C. and pressing with 2000 lbs. pressure, a hard metal composition analyzing nickel 6.05%, tungsten 15.94%, manganese .72%, balance 77.21% tantalum carbide was formed. The liquid alloy which was pressed out contained 69.84% nickel. This latter alloy was strongly magnetic, unlike the original 55% tungsten, 45% nickel alloy which is unmagnetic. The pressed out alloy contained 7.72% manganese besides 11.83% tantalum and 10.94% tungsten.

The hard composition, produced after this treatment resulting in the removal of part of the nickel, had a Rockwell hardness of 86½ A. The transverse break strength of this metal was high; a piece $\frac{3}{8}$ " thick x $\frac{1}{2}$ " wide supported $\frac{5}{8}$ " apart and pressed in the center with a Brinell ball was unbroken with 3600 kg. load.

Another piece was formed by heating the same powder to a higher temperature, by several hundred degrees; this produced a piece of my hard composition analyzing nickel .47%, tungsten 23.43% of Rockwell hardness 88 A.

These pieces were tested as lathe tools cutting steel of 302 Brinell hardness at speeds of above 300 feet per minute, on a lathe, the bits of metal being brazed to steel shanks for the purpose. They cut for 20 minutes without appreciable wear.

For some purposes it will be seen that the

harder composition from which more nickel has been liquidated is desirable, although to get ductile tungsten it is necessary to leave more than one thirtieth as much nickel as tungsten in the composition, and the durability as a tool is improved by having less than two-fifths as much nickel as tungsten.

A very important advantage of my improved hard composition of tantalum carbide, tungsten metal and nickel is that the relative proportions of tungsten and nickel are such that the nickel is absorbed in the tungsten and thus the coefficient of expansion of the tungsten-nickel is brought to substantially the same as that of the tantalum carbide and there is therefore no danger of cracking during the alternate heating and cooling of the material while it is being used for instance as a tool tip in cutting steel. If the nickel were not absorbed by the tungsten and if the tungsten were not present in sufficient amount relative to the nickel to be able to absorb the nickel, the higher coefficient of thermal expansion of the nickel, which is approximately two and one-half times that of the tantalum carbide, would cause such cracking as the result of thermal expansion. Such required proportions of tungsten and nickel are from one-thirtieth to two-fifths as much nickel as tungsten.

The presence of a small percentage of manganese in the final composition is beneficial from the standpoint of mechanical strength.

The alloy produced by the liquidation process, namely, about 70% nickel, 8% manganese, 11% tungsten and 11% tantalum is in itself a tough alloy which is particularly adapted to forming a union between the particles of tantalum carbide and tungsten, when it is not entirely pressed out.

I claim—

1. A hard unmelted composition of matter for steel-cutting tools, dies and the like, wherein the particles are welded together, comprising 71% to 92% of tantalum carbide, 28% to 6% of tungsten and one-thirtieth to two-fifths as much nickel as tungsten and from one-fourth to one-twentieth as much manganese as nickel.

2. A hard composition of matter for steel-cutting tools, dies and the like, comprising about 77% of particles of tantalum carbide, about 16% tungsten, about 6% nickel and about eight-tenths of one per cent of manganese.

3. A hard unmelted composition of matter for steel-cutting tools, dies and the like, wherein the particles are welded together, consisting substantially of tantalum carbide, tungsten metal, nickel and manganese, the tungsten comprising from 28% to 6% of the mass by weight, the nickel being present in amount of from one-thirtieth to two-fifths of the tungsten by weight and from one-fourth to one-twentieth as much manganese as nickel by weight.

4. A hard composition of matter for steel cutting tools, dies and the like, wherein the particles are in welded relation, comprising by weight from 71% to 92% of tantalum carbide, from 28% to 6% of tungsten, from one-thirtieth to two-fifths as much nickel as tungsten, and manganese in appreciable but minor quantities.

5. A hard composition of matter for steel-cutting tools, dies and the like, comprising by weight about 77% of particles of tantalum carbide, about 16% of tungsten, about 6% of nickel and manganese in an appreciable but minor quantity.

PHILIP M. McKENNA.