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MANUFACTURE OF CEMENTED HARD METALS, IN PARTICULAR FOR TOOL ELEMENTS

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This invention relates to the manufacture of cemented hard metals, in particular for tool elements.

Cemented hard metals are usually manufactured from one or more hard and refractory carbides, such as of tungsten, molybdenum, titanium, boron, columbium, tantalum and vanadium. The selected carbide or carbides, or solid solutions of two or more carbides are comminuted, then admixed if desired with other carbides and a binder essentially of the iron group, the mixture shaped under pressure and finally sintered preferably at a temperature between about 1350° to 1600° C.

Of the metals of the iron group cobalt was preferred, because of its property not to dissolve or to combine with carbon or the carbides to any great or detrimental extent. It cements however or superficially alloys very well with the carbides, and forms a satisfactorily tough binder phase in the sintered product.

Nickel does neither form nor dissolve carbides to any appreciable extent and is therefore also suited for a binder phase in cemented simple or multi-carbides. Its toughness is however not as great as that of cobalt.

Iron is of course a tough material, available in great quantities and inexpensive, compared with nickel and cobalt. Iron has however the property of forming or dissolving the hard carbides relatively easily. Although iron which contains combined carbon in amounts below 1.7% and preferably below .9% would form the best binder, there are no means available to date for preventing the iron from absorbing larger carbon amounts and thereby becoming brittle and less strong than compositions of iron containing a smaller percentage of carbon and therefore resembling steel. Furthermore, during sintering the iron takes away carbon from the hard carbides and reduces them to the pure metals to an undesirably great extent.

It is an object of the invention to make possible the use of iron containing any desirable amount of combined carbon, up to 1.7% and probably small amounts of other alloying elements well known for alloy steels, without decarburizing or detrimentally affecting the carbides to be cemented in a sintering process.

It is a further object of the invention to produce a binder phase substantially consisting of steel or alloy steel preferably in a synthetic manner without detrimentally affecting the carbides and without substantially changing the content on combined carbon of the binder phase.

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

According to the invention, the carbide or carbides are comminuted to a desired degree, so as to pass e. g. a 200 mesh sieve, and admixed with at least two types of binders in at least two subsequent mixing steps.

As a first type of binder a material is used which does not combine to any substantial or detrimental extent with carbon during final sintering and therefore cannot decarburize or deteriorate the carbides or diamonds at sintering temperatures.

As a second type of binder a material is used which is essentially tough and capable of alloying with the first type of binder. The second type of binder is chosen without having primarily regard to its property of combining with carbon.

According to the invention, in the first mixing step the comminuted carbide or carbides are ball milled preferably in the presence of a liquid such as water, carbontetrachloride etc. with the first type of binder until the carbide particles are densely covered with a film of that binder. Thereafter the carbide particles so covered with the first type binder are admixed preferably in a ball mill with the second type binder which is advantageously comminuted to the same or a higher degree of fineness than the carbide and first type binder, e. g. to a particle size less than 3 microns or recovered by chemical reduction in finest distribution. Thereby the second mixing step can be performed within a short period of time and without impairing the film previously produced on the carbide particles in the first and more protracted ball milling process.

Taking as a first example the manufacture of cemented tungsten carbide, one proceeds according to the invention advantageously as follows:

Tungsten carbide (WC) is prepared according to any suitable process and comminuted by wet or dry ball milling to an average particle size so as to pass a 200- to 325-mesh sieve, or even smaller, e. g. 8 to 3 microns. This powder is admixed with about 3% (by weight of the final body) of cobalt powder preferably of the same particle size as the tungsten carbide powder, and wet or dry ball milled for about 36 to 96 hours. Thereby the carbide particles are further comminuted and the cobalt smeared around them to form a thin coat or film on each carbide particle. Application of heat, up to about 400° to 600° C. and preferably towards the end of the ball milling and in a protective atmosphere, assists in completely

and densely coating the carbide particles with the cobalt. This powder is then admixed with about 3% to about 7% by weight of the final body of a powder consisting of 15 to 50 parts of pure or ferritic spongy iron powder and 50 to 85 parts of steel and/or alloy steel. The steel powder is preferably spheroidized by heat treatment. Thereby a powdery mixture is obtained which contains 94% to 90% tungsten carbide, 3% cobalt and 3% to 7% ferritic iron plus steel and/or alloy steel. The iron and steel (or alloy steel) powder are preferably of an average particle size e. g. from about 15 to 2 microns; the smaller particle sizes are advantageously obtained by ball milling the ferritic and steel powders for 12 to 48 hours in the cold or heat (up to about 600° C.) whereby the iron is ultimately smeared around the still further comminuted steel particles.

This ultimate powdery mixture is milled with or without balls or tumbled again but preferably only for about 4 to 24 hours in the cold. The carbide particles have been comminuted before by protracted ball milling to a size which can scarcely be further reduced in this last mixing process, and thus the carbide particles covered by the cobalt film substantially remain as they were, and the last mixing mainly produces the desired intimate mixture between the cobalt-covered carbide particles and the iron and steel powder. Particularly if the steel particles were previously spheroidized by heat treatment or during mixing with the iron powder at elevated temperature, they will not pierce the cobalt film to any detrimental extent during mixing. If the iron and steel powders have not been previously mixed, and both kinds of powders added to the coated carbide particles, by ball milling the mixture, the harder steel particles are further comminuted and eventually smeared with the soft pure iron, and in the same way some pure iron is smeared over the cobalt coat on the carbide particles.

The mixture so obtained is then pressed to shape, and finally sintered.

Assuming that the powdery steel contains .8% combined carbon, its melting point is about 1390° C., the lowest of all constituents of the mixture. Upon heating, it softens therefore first and diffusion of carbon contained therein into the pure iron starts. Thereby the melting point of the latter is decreased. However, no carbon diffuses into the cobalt film which is incapable of forming a carbide and the cobalt coat acts as a barrier against diffusion of carbon from the tungsten carbide into the ferritic iron and steel and thus prevents decomposition of the tungsten carbide. Diffusion of carbon from the steel into the iron starts well below 1000° C. and a liquid phase develops at 1121° C. Equilibrium is attained during sintering for about one to two hours at about 1200 to 1330° C., and about 1390° C. should not be exceeded during sintering if total melting of the iron binder is to be avoided.

The iron in contact with the cobalt films will, as soon as a liquid iron phase develops at about 1121° C., start to alloy with superficial layers of the cobalt film. Superficial layers of the cobalt film in contact with the carbide particles will start to melt and take some tungsten and carbide into solution only at about 1325° C. to 1350° C. Thus a liquid cobalt-tungsten-carbon phase will only develop when peak temperatures in sintering the body are reached, whereby again any detrimental effect of the iron phase upon the tungsten carbide phase is prevented. It should

be reiterated that, while iron combines easily with carbon at temperatures of and above about 1000° C., cobalt does not do so, and retains its solid state as a film around the tungsten carbide particles while the diffusion and sintering process in the iron phase proceeds. The cobalt therefore stays as a barrier between the iron phase and the tungsten carbide particles; it prevents the attack on the latter by the iron phase and thereby decomposition of the tungsten carbide into tungsten and carbon which may diffuse in relatively larger amounts into the iron phase and deteriorate the latter. This also prevents any detrimental decomposition of the tungsten carbide particles during sintering. Thus a sintered body is finally obtained which consists of as uniformly as possible distributed tungsten carbide grains thoroughly cemented with cobalt, and the latter alloyed with a steel binder phase resulting from the combination during sintering of the ferritic and steel powders.

In order to obtain best results, sintering of the pressed, shaped mixture should be performed in a particularly controlled manner and, of course, in a preferably gaseous or vaporous atmosphere which does not detrimentally affect the constituents of the mixture, such as desiccated hydrogen, carbon monoxide, nitrogen, etc.

The shaped bodies are preferably stoked through a furnace comprising different heating zones, so as to quickly heat the body to about 1000° C. to 1120° C., and thereafter more slowly to about 1200° C. (depending upon the average carbon content of the iron phase), so as to effect carbon diffusion and an as even as possible distribution of the carbon in the entire iron phase whereupon the thus presintered body enters a heating zone in which its temperature is raised to between about 1325° to about 1390° C. The body should be subjected to this heat for about 10 to about 30 minutes, if tungsten carbide is concerned in the presence of a binder composed according to the example stated and the weight of the body does not exceed about 3 to 50 grams. Thereupon the body is slowly to be cooled to a temperature below about 723° C. and at any rate slower than to effect quenching of the iron phase; thereafter the body might be cooled at any desired rate.

It is also within the invention to heat the cold pressed body fast to the final sintering temperature, within about 15 to 45 minutes, thereafter to expose the body to the final sintering temperature between about 1325° C. and about 1390° C. for about 15 to about 30 minutes, and thereafter to cool it fast; in such event the carbon will not be evenly distributed in the iron phase during final sintering and the latter also quenched or nearly quenched. However, thereby any appreciable diffusion of carbon from the tungsten carbide into the iron phase is definitely prevented while cementing of the cobalt with the carbide particles, alloying of the cobalt with adjacent iron and steel particles, and sintering together of the iron and steel particles is satisfactorily effected. Thereafter diffusion and as even as desired distribution of the carbon within the iron phase alone can be conveniently obtained by annealing the body at a temperature up to about 500° to below 720° C., preferably for several hours; within that relatively low temperature range the tungsten carbide cannot decompose and none of its carbon diffuse through the intermediate cobalt layer or cobalt-tungsten-carbon eutectic into the iron (steel) binder phase.

By such a procedure the high heat furnaces of limited capacity will be used with utmost efficiency and greatest output achieved. Annealing can be effected in chambers of large capacity at relatively low temperatures and corresponding small cost, and any desired structure of the iron (or synthetic steel) phase produced.

In the way described in the above example a binder phase substantially consisting of steel or alloy steel and cemented with the carbide particles by means of an intermediate cobalt phase can be obtained. The steel may be of any suitable composition and contain from .1% to 1.7% carbon; however a carbon content well below .9% is preferable.

It is to be understood that the ferritic iron is added in order to obtain a more easily compactible mixture, and its amount is therefore to be chosen accordingly. The smaller the absolute amount of the iron phase, the larger should be the percentage thereof consisting of substantially pure or ferritic and accordingly pliable iron.

Therefore, if the iron phase is very small, and amounts e. g. to only about 3% of the final body (to which e. g. about 2% to 3% cobalt are to be added), one may also proceed by admixing the carbide particles, coated with cobalt, with substantially pure iron powder only to which solid carbon in desired amount is added.

Taking for instance a final mixture comprised of 2% cobalt, 4% iron and 94% tungsten carbide, the iron powder is prepared separately by admixing it with solid carbon, such as lamp black in the amount required to form with the iron the desired steel upon heating. Thus about .2% to .8% carbon may be admixed to the iron by milling it with or without balls for about one or several hours, whereupon this iron-carbon mixture is admixed with the cobalt-coated tungsten carbide particles by milling them with or without balls for a few hours. Thereby the soft iron containing admixed carbon will be sufficiently smeared around the cobalt-coated tungsten carbide particles so as to allow pressing and sintering. During preferably fast heating to sintering temperature, the carbon will combine with the iron in the desired manner, particularly as soon as temperatures of about 1000° C. are exceeded. Again the cobalt coat will form a barrier against diffusion of carbon from the carbide particles into the iron and vice versa during sintering for about 15 to about 30 minutes below about 1400° C.

Instead of admixing solid carbon to the iron powder, an organic binder or slip may be admixed or stirred into the mixture of iron and cobalt-coated carbide particles; this organic substance of course contains carbon, and upon decomposition and volatilisation of this binder, respectively, the carbon contained therein combines with the iron. Suitable binders of this type are paraffin, naphthalene, tar and other carbonaceous materials which are viscous or fluid at room or slightly elevated temperature and decompose below about 1000° C. They also facilitate molding to shape, and, if desired, compacting the molded mixture upon heating to about 180° to 400° C. so that the compact can be machined to exact shape before final sintering.

Taking as another example cemented tantalum carbide, it is known that it can be cemented by cobalt, but perhaps in a better way by nickel. Nickel does not form stable carbides at elevated

temperature and is therefore usable to the same effect as is cobalt.

Therefore, in cementing e. g. 90% tantalum carbide with 3% nickel and 7% steel, one proceeds the same way as described before with reference to tungsten carbide, cobalt and iron. First the tantalum carbide particles are comminuted to a very small size and densely coated with nickel, and thereupon the nickel-coated tantalum carbide particles are admixed with an equally comminuted mixture of ferritic iron and steel or alloy steel particles. Sintering is performed the same way as described above for cemented tungsten carbide, the final temperatures to be held below about 1400° C. All the detailed exemplifications stated above with respect to cementing tungsten carbide likewise apply to cementing tantalum carbide. It should also be understood that instead of nickel, cobalt can be used with tantalum carbide to the effects described above.

If another binder phase than of steel or alloy steel is used, such as cobalt steel, one proceeds advantageously as follows. The carbide particles are admixed with about 2% to 3% cobalt, finely comminuted to a particle size of below 8 microns and preferably a few microns or a fraction of 1 micron, and covered with a dense cobalt film, preferably at elevated temperature, up to about 400 to 600° C. Separately a mixture of iron, carbon and tungsten is prepared, comprising about 16 to 30 parts of tungsten, about .3% to .45% carbon, and traces to a few per cent of vanadium and chromium as the case may be.

Tungsten $\alpha\alpha$ powder of finest particle size is used, of a few microns or a fraction of one micron, and admixed in a ball mill with the pure iron and the other components stated until the tungsten powder is coated with the pure iron containing the other admixtures. Thereupon the cobalt-coated carbide particles are admixed with 3 to 7% by weight of the final body of said separately prepared mixture, by milling for a few hours with or without balls or tumbling, the mixture shaped and finally sintered at a temperature not exceeding about 1400° C. (and preferably 1390° C.) for 15 to 60 minutes. If a shorter period of sintering is used, the product is cooled preferably rapidly and thereafter annealed in order to obtain as uniform as possible distribution of the carbon and other components in the iron binder phase and to produce a desired steel-like structure.

In the above example it was assumed that cobalt of the film will alloy with the iron binder phase to an extent to form therewith the desired cobalt-steel composition. It will be appreciated that during sintering and/or annealing a substantial amount of the cobalt film is given opportunity to diffuse into the iron phase and to bring about the desired cobalt-steel composition which comprises about 3% to 30% cobalt, 12% to 20% tungsten and well below .9% carbon, besides other alloying admixtures. If diffusion to the desired extent of cobalt from the coat is not attained during sintering and possibly subsequent annealing, cobalt in sufficient amount should be admixed to the separate mixture of iron before it is added to the cobalt-coated carbide powder. As to the temperatures and effects all the details pertain as stated above to the manufacture of cemented tungsten carbide.

If a binder phase consisting of copper-nickel-steel is desired, the composition of which is in general 9% to 19% Cu, 22% to 45% Ni, .2% to

.5% C, traces of phosphorus, sulphur, silicon, manganese, and balance iron, one proceeds advantageously in the following manner. The carbide particles are comminuted and coated with 2% to 3% by weight of the final body of nickel, and separately a mixture is prepared consisting of copper, iron, carbon and other constituents within the ratio stated above to form upon sintering, and, if desired, annealing, a copper-nickel-steel phase. Nickel may be added to this separate mixture to the extent as not available from the coating on the carbide particles. The nickel-coated particles are then admixed by milling with or without balls for a few hours or tumbling with the above separately prepared mixture and quickly heated to a temperature between about 1225° to 1350° C. The shape is kept at that temperature for about 15 to 30 minutes. If subsequent annealing is applied, sintering may be effected for the shortest possible period, and the body quenched.

It will be understood that in the use of cobalt steel or copper-nickel-steel as exemplified above, ferritic iron and solid carbon are preferred in the initial mixture. However, here again the separate mixture may consist in part of ferritic iron and in part of steel containing combined carbon in such an amount that upon sintering and, if desired, annealing, the average content on carbon of the binder phase will be the desired one. Therefore, if the separate mixture consists of e. g. 50% pure iron, the admixed steel particles should contain .7% carbon if the average carbon content of the final binder phase is to be .35% carbon.

Since copper is present in the copper-nickel-steel, the amount of ferritic iron can be made quite small since the added copper is pliable and assists in molding a coherent compact. Thus, a separate mixture amounting to 7% of the final body to be sintered, may comprise e. g. 1% to 1.4% Cu, 2% to 2.5% ferritic iron and 4% to 3.1% steel or alloy steel. Any other way of synthetically arriving at the desired composition of the final binder phase can be used. During sintering the nickel will serve as a barrier for the diffusion of carbon from the carbides into the iron phase and vice versa.

One proceeds in a similar way if other kinds of binder phases are desired.

If an alloy of 15% to 45% Cu, 2% to 10% W and 50% to 78% Ni is desired, one proceeds preferably in preforming by melting this alloy and comminuting it to a small particle size, approximately the same as the carbide particles. The latter are comminuted by ball milling to the desired size in the presence of nickel. Taking into consideration that some alloying by diffusion and melting will occur between the coat on the carbide and the alloy when sintered to about 1050° to 1325° C., the content of the separately prepared alloy on nickel is to be reduced by the amount of the constituent which will be supplied from the coat of the carbide particles during sintering; the amounts of the constituents so derived from the coat can be easily established by experiment and are always smaller than the amount used for coating the carbide particles in order to maintain a barrier between the latter and the alloy and thereby to prevent carburisation of the tungsten present therein.

If a chromium-steel is intended to be used for the binder phase, a pre-alloy of chromium and steel is preferably prepared, consisting of about

.8% to 6% chromium, balance steel containing about .2% to .8% carbon and traces of other constituents of such type of steel (P, Mn, S, Si, and sometimes W). This pre-alloy is comminuted to a particle size of about 5 microns and below, and admixed with an equal amount of pure iron in a ball mill whereby the latter is smeared around the alloy particles which are further comminuted. The thus separately prepared powder is admixed with a powder of carbide particles coated with 2% to 3% nickel, by milling with or without balls for a few hours or tumbling, and the pressed to shape mixture sintered at a temperature preferably not to exceed about 1325° C. for about 15 to 30 minutes, if an average weight—as in all the examples given herein—of the shape of about 5 to 50 grams is not exceeded. During sintering sufficient nickel diffuses into the alloy and carbon from the pre-alloy into the pure iron so as to obtain a satisfactorily sintered body, while ultimate uniform distribution of the carbon introduced by the pre-alloy into the binder phase is advantageously attained by subsequent annealing within the temperature ranges stated above.

If nickel-steel is to be used as a binder, preferably a pre-alloy of nickel, iron and carbon and other constituents usual for this type of steel is formed by melting and subsequent comminuting, and the pre-alloy admixed with the carbide particles which were coated by nickel in a protracted ball milling process, preferably at elevated temperatures, as described hereinbefore. From the nickel coat nickel will alloy with the particles of the pre-alloy during sintering and subsequent annealing to form the desired binder phase.

Here again the binder phase can be produced in a synthetic manner e. g. by admixing powdery ferritic iron with powdery steel containing a proper excess of carbon and the other alloying substances of nickel steel, and powdery nickel, and admixing the sufficiently comminuted powdery mixture with nickel-coated carbide particles, pressing the mixture to shape and sintering it for 15 to 30 minutes below 1400° C., cooling and, if necessary, annealing.

If a "Stellite" binder is desired, comprised of 50% to 75% Co, 8% to 15% Cr and 8% to 30% W (and preferably some Mo), one proceeds preferably by separately preparing by melting a kind of "Stellite" which is deficient in cobalt, comminuting it and admixing this powder with cobalt coated carbide particles. Sintering of the shape is thereafter performed at about 1400° C. for 15 to 45 minutes, whereby some of the cobalt coating of the carbide particles alloys with the "Stellite" particles and makes up for the deficiency of cobalt in the "Stellite" composition.

Here again care must be taken that not the entire coat alloys with the "Stellite" in order to prevent carburisation of the tungsten (or molybdenum) contained in the latter. This can be attained by keeping the sintering temperature well below the melting point of cobalt and correcting the composition of the binder phase, if needed, by subsequent heat treatment which in this case may be performed at temperatures exceeding annealing temperatures of an iron phase, but well below 1250° C. to 1325° C. at which temperatures cobalt and carbides form a liquid phase in contacting layers. A subsequent heat treatment at about 1100 to 1200° C. for approximately 1 to 8 hours is preferred.

If the manufacture of cemented multi-carbides

is intended, it is preferred by the invention to preform solid solutions of the carbides at elevated temperatures well above 1600° C. up to about 2600° C. in a protective atmosphere, to comminute the carbide solid solutions, add there-
to other carbides, if desired, and then to ball mill the carbide material with cobalt, nickel, nickel-copper, etc. as the case may be in order to obtain a power of a particle size between about 5 microns to a fraction of 1 micron and to coat the carbide particles with the softer barrier material. The coated carbide particles are then admixed with a comminuted pre-alloy, or a powder adapted to form synthetically the desired binder phase, and sintering, cooling and subsequent heat treatment (if desired) are effected as stated above for simple carbides.

The period of sintering previously suggested will also suffice for mere cementing the multi-carbides if no additional solid solution formation of the carbides is intended. If additional solid solutions between the carbides are to be produced, sintering at highest temperatures is to be protracted to about twice to about four times the sintering period recommended above for simple carbides. However, if binder phases containing admixtures melting below about 1400° C. are concerned, such as constituents like copper, tin and zinc, such protracted sintering is of no significant effect as to new solid solution formation, and therefore solid solutions of the carbides should be preformed to the entire amount desired to be present in the final body.

It will be appreciated from the above that according to the invention hard and refractory particles are bonded by means of a lower melting binder in a sintering process. The hard particles consist of refractory carbides of boron, titanium, silicon, tantalum, columbium, vanadium, chromium, tungsten and/or molybdenum, solid solutions and complex compounds thereof, such as double carbides. The hard particles are comminuted preferably to below 1 micron diameter and as densely as possible coated by a film of a "barrier" material. This term which is also used in the appended claims, is to be understood to mean a material which does not chemically combine to any substantial or detrimental effect with carbon, or boron, or nitrogen, as the case may be, under the temperature conditions of a sintering process. As barrier metals cobalt, nickel and copper are to be considered in the first place. They neither chemically combine nor form solid solutions to any substantial extent (exceeding about 8 to 10%) with the refractory metals used to form the hard carbide, a nitride or boride particles, and therefore alloy, if at all, only superficially and in particular they form eutectics with the hard particles so as to be firmly bonded with them.

The binder phase proper consists either entirely or in part of other substances than the barrier metal, but is in any event capable of alloying or agglomerating with the barrier metal at least in superficial contacting layers. Thereby a firm bond between the barrier and the binder phase is secured. As a consequence, the barrier phase prevents detrimental changes in composition of both the hard particles and the binder phase proper and serves as a cementing intermediary between the binder phase proper and the hard particles. In a broader sense the binder phase of course also comprises the barrier phase as contrasted with the hard particle phase.

The binder phase proper is obtained from pow-

dery constituents of an average particle size advantageously about the same as the hard particles. The powdery binder phase may either consist of powders of the completed binder, or of a mixture of powders which upon heat treatment results in the ultimate desired structure and composition of the binder phase.

In sintering, temperatures are to be attained at which the barrier metal cements with the hard particles and therefore plastification or incipient fusion is caused in surface layers of the barrier metal contacting the hard particles. In the same way the sintering temperature must be sufficiently high so as to cause by diffusion or fusion at least superficial alloying of the barrier metal with constituents of the binder phase proper; if the latter consists of two or more kinds of powders, also alloying or agglomeration of the particles of the latter powders is to be effected. Here again it is sufficient that incipient fusion of at least one constituent of the binder is caused while complete melting of the barrier material and binder phase proper should advantageously be avoided by properly timing the sintering period.

The temperature and duration of final sintering is to be chosen so as to effect bonding of the barrier metal and hard particles. These conditions may be insufficient to obtain the desired thorough alloying between the barrier and/or binder phase material and/or to give the latter the desired structure. In such cases subsequent or prior to final sintering heat treatments are applied at temperatures and of durations which secure proper alloying, ultimate composition and desired structure of the binder phase but do not detrimentally affect the bond between the hard particles and the barrier metal, and therefore should be considerably below final sintering temperatures. If for instance uniform distribution of the elements, e. g. carbon within the binder phase proper is intended, the shape can either be presintered or annealed or both, at temperatures considerably below final sintering temperature.

It should be understood that the invention is not limited to any exemplification or illustration herein shown, but to be derived in its broadest aspect from the appended claims.

What I claim is:

1. In a method of producing cemented hard metal compositions substantially comprising a carbide substance selected from the group consisting of carbides of boron, titanium, silicon, tantalum, columbium, vanadium, chromium, tungsten and molybdenum as a major portion and a considerably lower melting, substantially metallic binder phase as a minor portion, the steps of densely coating the particles of said selected carbide substance having an average diameter of about 8 microns to a fraction of 1 micron, with metal selected from a first group of metals essentially incapable of forming carbide and consisting of cobalt and nickel, the amount of said metal being appreciable and a fraction, about two thirds as a maximum, of said binder phase, admixing said coated carbide particles with pre-powdered components of the balance of said binder phase, said components selected from a second group of tough metallic substances capable of alloying with metal selected from said first group and consisting of iron, ferrous compositions of the type of steel including alloy steel and compositions of a tungsten-chromium-cobalt base, pressing the mixture so obtained to

shape, and finally sintering it at temperatures below the prevailing melting temperature of said selected powdery components between about 1050° to about 1390° C., so as to bond the metal selected from said first group with said carbide particles and to alloy it with the powdery substance selected from said second group, and also to agglomerate the latter, so that on cooling a dense and tough body is obtained.

2. A sintered, cemented hard metal composition substantially comprising particles of a carbide substance selected from the group consisting of carbides of boron, titanium, silicon, tantalum, columbium, vanadium, chromium, tungsten and molybdenum as a major portion and a considerably lower melting, substantially metallic binder phase as a minor portion, said particles contacted by and densely coated with metal selected from a first group of metals essentially

incapable of forming carbide and consisting of cobalt and nickel, the amount of said metal being appreciable and a fraction, about two thirds as a maximum, of said binder phase, said metal bonded with said particles and alloyed, at least in contacting surface layers, with the balance of said binder phase, said balance selected from a second group of tough metallic substances capable of alloying with metal selected from said first group and consisting of iron, ferrous compositions of the type of steel including alloy steel, and compositions of a tungsten-chromium-cobalt base.

3. In a method as described in claim 1, the application of heat of a temperature up to about 400° to 600° C. in the step of densely coating the particles of said selected carbide substance.

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