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PROCESS OF MANUFACTURING A COMPOSITION OF MATTER

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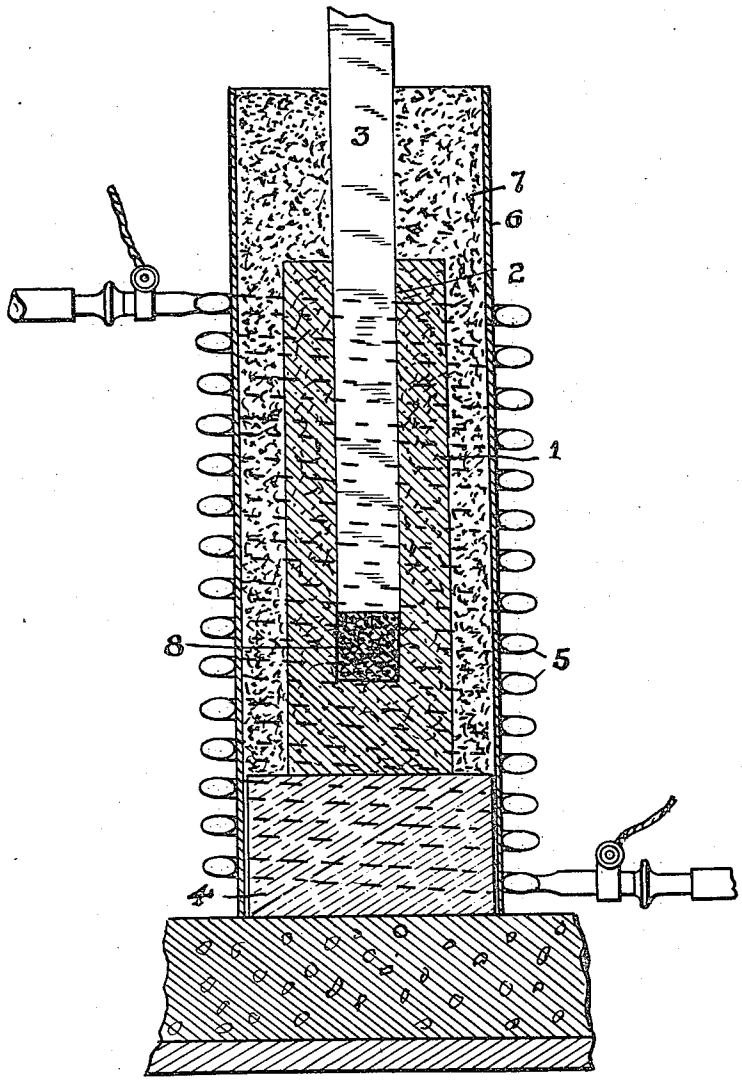

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PROCESS OF MANUFACTURING A COMPOSITION OF MATTER

Application filed October 23, 1930. Serial No. 491,734.

This application is a continuation in part of my pending patent application Serial No. 400,159, filed October 16, 1929.

The object of this invention is to form a material for tools, dies and like purposes which is superior to any heretofore known in the metallurgical science and art.

Cutting tools have commonly been made of steel and "high speed steel". Again, cast alloys known as stellites have been produced for this purpose. Also melted and cast alloys largely of such metals as tungsten, molybdenum and tantalum, with carbon and sometimes other metals and/or metalloids in minor quantities have been proposed as tool materials. Also tungsten carbide sintered with cobalt has been employed as a tool material.

The improved composition which is the subject matter of the present application is superior to all of the hitherto known tool materials. It is harder than hardened steel or than high speed steel. The latter in their hardest condition measure about 69 on the Rockwell C scale, while my improved composition has a hardness of 70 to 76 on the Rockwell C scale.

My improved composition is superior to high speed steel in its metal-cutting ability, as it does not fail as a tool point when cutting steel of 440 Brinell hardness at speeds exceeding one hundred feet per minute, while tools of high speed steel fail in less than thirty seconds when used under similar conditions.

My improved composition is superior to stellites and other known cast alloys of tungsten and carbon, either with or without other metals, as regards durability and furthermore it is free from inequalities due to crystallization and segregation inherent in all cast products which products are also usually impaired by blow holes.

My improved composition is superior to cemented carbide alloys formed by heating, in which pulverized tungsten carbide is sintered with a softer metal having a substantially lower melting point. The metal cobalt has the properties of having a substantially lower melting point than that of tungsten carbide.

However, the use of a relatively soft metal such as cobalt as a binder or cementing substance for the tungsten carbide particles is attended by important disadvantages, and the percentage of such cementing material must be regulated to provide the necessary toughness or the tools will be brittle.

Thus when a wear-resisting cutting edge is desired as low as 3% cobalt is customarily employed, although 13% is necessary in tools of sufficient toughness for lathe work in cutting phosphor bronze and cast iron with intermittent cuts. With 13% of cobalt the metal will not serve as a lathe tool point for cutting hard steel but invariably develops "cratering" immediately back of the edge due to wear. Also the point wears rapidly in front destroying the clearance and cutting efficiency. I attribute this failure to the tearing out of the grains of tungsten carbide from the soft metal, cobalt, cement.

The usefulness of cobalt cemented or sintered tungsten carbide tools is thus limited not by the inherent qualities of tungsten carbide but by the relative weak metal cobalt.

In the manufacture of my improved composition I employ a tungsten carbide comprising two atoms of tungsten and one atom of carbon or W2C together with the metal tantalum. The use of WC would result in such brittleness as to render the composition unfit for the purposes in view.

In the manufacture of my improved composition I do not use as a binder or cement for the tungsten carbide particles a metal, such for instance as cobalt, which has a lower melting point than the particles which it cements together, but I combine with the tungsten carbide a metal, tantalum, which has a higher melting point than has the tungsten carbide. Thus the tungsten carbide has a melting point of approximately 2800° C. while tantalum metal has a melting point of 2850° C.

In the production of my composition I employ a temperature less than that necessary to form an alloy of the materials and also materially less than that required to produce a sintering effect.

In the production of my improved composition I employ sufficient pressure and in-

duced high frequency eddy currents of electricity of sufficient voltage and alternations per second to produce a welding action between the particles by a local surface phenomenon. The microscopic sparks produce very unusual conditions locally, evidently vaporizing and re-condensing these difficult to melt metals at the surfaces, because the resulting composition has a density slightly greater than the mean calculated density of the constituents.

The temperature involved is very materially lower than the melting temperatures of any of the constituents of my composition.

After the product is formed, it is an unmeltable solid at the temperature at which it is formed, and pieces of my composition returned to the sparking chamber, while other compositions of the same kind are being prepared in the chamber, remain unmelted and unaffected.

For example I have produced my improved composition at an average body temperature materially less than the melting point of any of the ingredients namely about 2000° C. in the presence of a pressure of about 4000 pounds per square inch and induced high frequency eddy currents of electricity of about 7700 volts and as high a frequency as is reasonably attainable, although 10,000 to 100,000 alternations per second may be satisfactorily employed.

It is obvious that the amount of pressure required depends on the mass of the composition being formed. A small or thin piece of composition obviously requires less pressure.

The voltage and frequency should be sufficient to produce the requisite local surface sparking phenomenon. Such high frequencies may be obtained by using a high frequency induction coil with high voltage transformer, condensers of sufficient capacity and a mercury arc gap. The object in view in using such high frequency is not that of heating so much as it is to obtain a welding action between the particles of tantalum and the particles of the tungsten carbide. This high frequency produces the sparks which are requisite for the welding action. Such interior sparking cannot be obtained by the use of resistance heating by electricity.

All three conditions may be obtained in the following manner. A coil of flattened 1/4" copper pipe is wound around a 4 1/8" inside diameter making twenty-six turns with the succeeding layers of the copper coil separated by a space of 1/16". The coil is shellacked and suitable connections made at the ends by which water may flow through the center of the flattened copper pipe which is not flattened sufficiently to impede the flow; also electric connections are made at either end of the coil. A fused silica tube 4 1/16" outside diameter and about 13" long with wall thickness of about 1/16" is placed in the copper coil and a refractory block about 3 3/4" in diameter and 2" thick is inserted at the bottom of the silica tube, resting on a substantial stone block supported by steel plates. A 2 1/2" cylinder of carbon 8" long is cut out with a hole of the cross section desired in the bit of hard metal. The powdered tungsten carbide and the finely divided tantalum to the specified amount carefully mixed is inserted in the hole in sufficient quantity so that the resultant bit of hard metal is of the desired size calculating from the specific gravity of the expected product which will vary from 11 to 16 depending upon the proportions of the ingredients. A ram also of carbon is fitted into the hole and a screw arranged above the ram so that a pressure of 4000 pounds per square inch may be applied by hand. The high frequency electric current may be obtained from a transformer and condensers of sufficient capacity, or from known ways by rotary converters. The carbon mold is insulated from the silica tube by surrounding it with carbon black.

In the accompanying drawing, wherein the apparatus is illustrated in vertical section, 1 represents the mold; 2 the hole bored therein; 3 the ram; 4 the refractory block upon which the mold rests; 5 the coil of a high frequency electric furnace; 6 the fused silica tube in which the mold assembly is packed in the carbon black insulation 7, and 8 is the material to be treated.

The electric eddy current at the rate of 5 kilovolt amperes is applied and continued for twenty-five minutes, when pressure is applied to the ram, gradually increasing to 4000 pounds, until at the end of forty minutes the current is turned off, the mold removed from the carbon black and allowed to cool.

On breaking the carbon mold the metal product is found to be of great density, absolute uniformity and capable of taking a keen edge on a silicon-carbide grinding wheel. Its size is close to the exact size of the mold.

These metal tips may be attached as by brazing to suitable shanks to form cutting tools.

Steel may be cut with these tools at speeds heretofore unattainable. Intermittent cuts on hard steel have been made with my new composition, a thing impossible with cobalt-cemented tungsten carbide tools.

The composition of my produce may be varied somewhat. Thus I may and do use from 15% to 30% tantalum and the remainder tungsten carbide, W2C, but I find that I obtain the best results by the use of from 18% to 25% tantalum and the remainder of W2C.

I have attempted to produce my improved composition by the alloying or melting method but the resultant has been brittle and worthless for tool purposes.

There have been efforts made by others to combine tantalum and tungsten carbide into an alloy by the casting method, the mixed constituents being entirely melted and reduced to a liquid condition. However a cast product containing 20% of tantalum, for example, cannot contain more than 1.7% of carbon and when containing 35% of tantalum cannot contain more than 1.50% carbon. On the contrary, in my process a composition containing 20% of tantalum contains 2.52% of carbon and when containing 25% of tantalum contain 2.37% of carbon. The result of having a higher tenor or carbon is of course that the composition in harder.

This relative high percentage of carbon has been impossible with the cast alloys because when this carbon content is increased beyond the relative percentages stated below the material is crystalline and brittle. There have been previously disclosed in the prior art in connection with cast tungsten carbide tantalum alloys the following compositions:—

Tungsten	Tantalum	Carbon
Per cent	*Per cent*	*Per cent*
92.3	5	2.7
87.9	10	2.1
78.3	20	1.7
63.5	35	1.5
49.3	50	0.7
24.2	70	0.8

By employing my process I am enabled to obtain the following ultimate compositions:—

Tungsten	Tantalum	Carbon
Per cent	*Per cent*	*Per cent*
77.9	20	2.52
72.75	25	2.37
67.50	30	2.21

It is thus evident that my improved composition is fundamentally different from the cast alloy since in the case of the cast alloy to obtain the desired toughness the content of carbon must be kept within much lower limits than is the case with my improved composition which is not produced by the melting or casting process.

When tested on the ordinary Rockwell diamond point hardness test with a 150 Kg. load, such as is used in testing hard steel, my improved composition is found to have a very high compression hardness and to be of substantial uniformity. The penetrator does not become shipped or shattered, and the impression is clean cut.

On the contrary, if a like load be imposed on the penetrator in testing other tool compositions the penetrator will be chipped and shattered and the impressions are irregular. This is due to the great inequality in compression hardness between contiguous particles of the compositions. Thus in the case of a cemented, that is sintered, cobalt-tungsten carbide composition and also in the case of a cemented, that is sintered, nickel-tantalum carbide composition, the cementing material, which is cobalt in the one instance and nickel in the other instance, has a very much lower compression hardness than the other constituent of the composition and thus the penetrator tends to slip or jump from a harder to a softer particle.

This is proof of the superior toughness of my composition.

The same failure under Rockwell diamond point test under a like load is experienced in the case of the melted and cast alloys of tungsten, tantalum and carbon, the failure demonstrating the brittleness of these products.

It is well known that a composition of these high melting point metals with carbon which has been formed by melting has a coarse crystalline fracture, and is unsuited for a tool material. By my process I avoid this crystallization and a fracture of my metal shows a fine silky conchoidal structure. This discloses a reason for the relative toughness of my composition.

I claim:—

1. The process of manufacturing a material for tools and the like wherein the particles are welded together, which process comprises subjecting to pressure a mixture comprising finely divided tungsten carbide and tantalum and simultaneously subjecting the mixture to high frequency electric currents in the presence of temperatures materially less than the melting points of either of the said ingredients.

2. The process of manufacturing a material for tools and the like wherein the particles are welded together, which comprises subjecting a mixture comprising finely divided tungsten carbide and tantalum to a pressure of approximately four thousand pounds per square inch and simultaneously subjecting the mixture to high frequency electric currents in the presence of temperatures materially less than the melting point of either of said ingredients.

3. The process of producing a hard composition for steel-cutting tools, dies and the like wherein the particles are welded together, which consists in subjecting a mixture of approximately from 15% to 30% of finely divided tantalum metal and the remainder of finely divided tungsten carbide to pressures sufficient to compact the particles into close surface contact and to welding temperatures which are less than the melting point of either of said ingredients.

Signed at Pittsburgh, Pa., this 23rd day of Oct. 1930.

PHILIP M. McKENNA.