

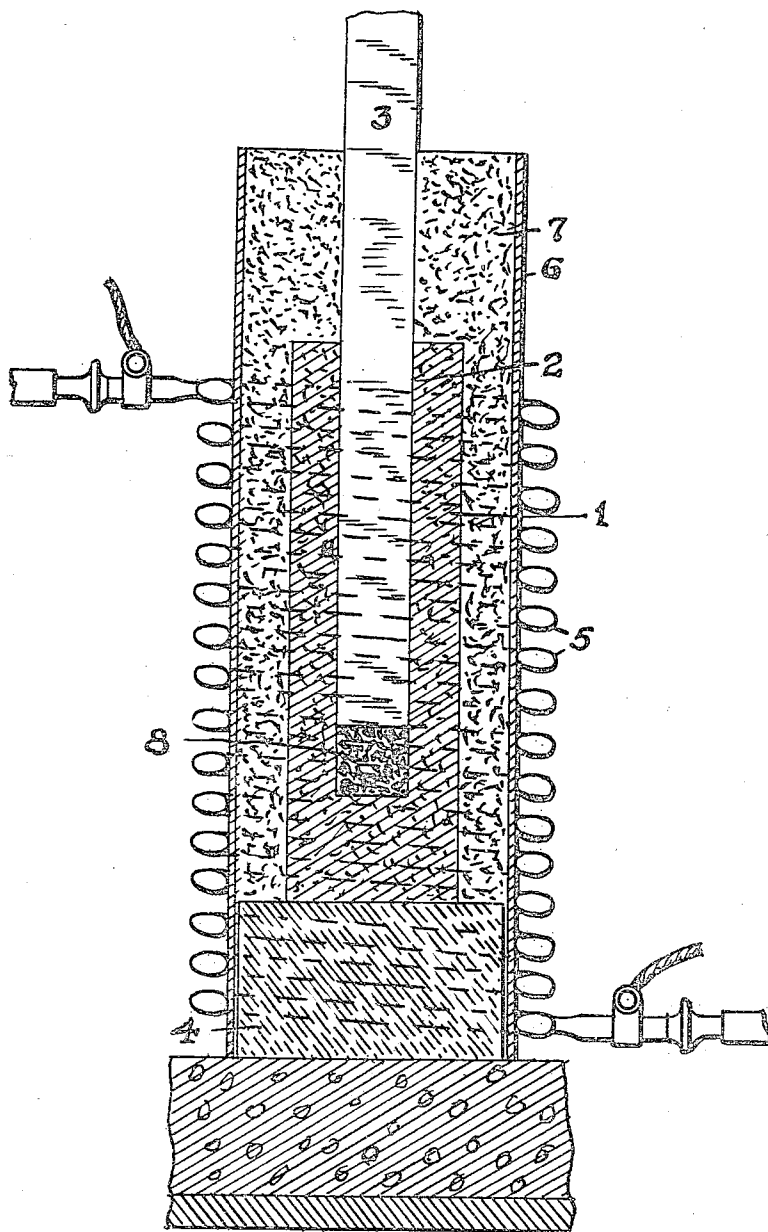
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COMPOSITION OF MATTER

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UNITED STATES PATENT OFFICE

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COMPOSITION OF MATTER

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

5 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 cast alloys largely of such metals as tungsten, molybdenum and
10 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.

15 I have previously produced, by means of the new process which I have discovered, namely by high frequency welding on a microscopic scale under pressure, a composition of tantalum metal and tungsten carbide
20 which is superior to cobalt cemented tungsten carbide compositions for steel-cutting tools.

The improved composition which is the subject matter of the present application is
25 superior to all of the hitherto known tool materials. It is harder than hardened steel or high speed steel. The latter in their hardest condition measure about 69 on the Rockwell C scale, while my improved composition
30 has a hardness of 71 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
35 steel of 440 Brinell hardness at speeds exceeding one hundred feet per minute, while the tools of high speed steel fail in less than thirty seconds when cutting under equal conditions.

40 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
45 cast products which products are also usually impaired by blow holes.

My improved composition is superior to cemented tungsten carbide alloys formed by
50 heating, in which pulverized tungsten car-

bide 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
55 of the tungsten carbide. The presence of a relatively soft metal like cobalt as a binder is a disadvantage, and the percentage of such binder metal must be adjusted to give the necessary toughness or the tools will be
60 brittle.

Thus when a wear-resisting edge is desired as low as 3% cobalt is customary, although 13% is required by the tools of sufficient toughness for lathe work in cutting phosphor
65 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, invariably showing a "cratering" immediately back of the edge, due to wear. Also the
70 point wears rapidly in front destroying the clearance and cutting efficiency.

I attribute this to the tearing out of grains of tungsten carbide from the soft metal binder.

The usefulness of cobalt cemented tungsten
75 carbide tools is thus limited not by the inherent qualities of tungsten carbide, but by the relatively weak metal cobalt.

My improved composition is superior to the composition described in my co-pending
80 application in which tantalum metal and tungsten carbide are formed into a composition by my process by high induced eddy currents of electricity. The latter cuts steel
85 without cratering, but is not tough enough to stand up cutting hardened steel with the "lipped" point which is essential to curl the chip and thus dispose quickly of the metal removed which is otherwise dangerously shot
90 out in straight strips of hot and sharp cuttings, dangerous to the operators of the lathes.

This difference in toughness I attribute to the fact that tantalum metal has a cubic
95 atomic lattice while tungsten carbide has a hexagonal lattice and thus they do not form as tough a composition as the carbide of tantalum, columbium or vanadium and tungsten metal which latter all have a cubic crystal-
100

line system as disclosed by X-ray spectrography.

In my present composition I employ metallic tungsten or metallic molybdenum or both, together with a mono-carbide of a metal of the first column in the fifth group of elements of Mendeleeff's periodic table. Such known carbides are vanadium carbide, columbium carbide and tantalum carbide.

The melting point of tungsten is 3370° C., of molybdenum 2620° C., while the carbides of tantalum and columbium are reported to have melting points of 4100° absolute and vanadium carbide is reported to melt at 2750° C. I employ from 30% to 70% of the tungsten and from 70% to 30% of the carbide of the other ingredient or ingredients the percentages being atomic. Where molybdenum replaces the tungsten in whole or in part an atomic weight of molybdenum equal to the atomic weight of the tungsten replaced either in whole or in part is used. Thus 96 parts of molybdenum would replace 184 parts of tungsten.

In the manufacture of my improved composition I use no so-called metal binder or cement having a substantially lower melting point than tungsten carbide.

In the production of my improved composition of matter I employ sufficient pressure and high frequency induced 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 surface, because the resulting composition of matter has a density actually slightly greater than the mean calculated density of the constituents.

The temperature involved is materially lower than the melting temperature of any of the ingredients of my composition. And after the product is formed, it is an unmelted solid at the temperature at which it is made. Pieces put back in the sparking chamber while other metal of the same kind is being prepared in the chamber remain unmelted, thus proving that the formed composition as well as the ingredients separately are not heated to the melting point.

For example I have produced my improved composition at a 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 high frequency induced 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.

The voltage and frequency should be sufficient to produce the requisite local surface sparking phenomenon. Such high fre-

quencies 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 tungsten and/or molybdenum and the particles of the 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 $\frac{1}{4}$ " copper pipe is wound around a $4\frac{1}{8}$ " inside diameter making twenty-six turns with the succeeding layers of the copper coil separated by a space of $\frac{1}{16}$ ". The coil is shelled and suitable connections made at the ends of 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 ends of the coil. A fused silica tube $4\frac{1}{8}$ " outside diameter and about 13" long with wall thickness of about $\frac{3}{8}$ " is placed in the copper coil and a refractory block about $3\frac{3}{4}$ " 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 $2\frac{1}{2}$ " 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 and/or molybdenum metal and the finely divided tantalum carbide 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 induced electric eddy currents at the rate of 5 kilo volt amperes are applied and continued for twenty-five minutes, when pressure is applied to the ram, gradually in-

creasing 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.

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

10 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 the metal product may be varied somewhat, but a metal comprising an atomic equivalent weight of tungsten or molybdenum, to a molecular equivalent weight of the mono-carbide is typical. Thus 184 parts of tungsten with 193 parts of TaC may be used. The useful limits of the composition lie between six tenths of an atomic equivalent of tungsten or molybdenum to one and four tenths atomic equivalents of the same, to which a quantity of the mono carbide in molecular equivalent weight inversely varying from one and four tenths molecular equivalent weights to six tenths of an equivalent weight is added.

Six-tenths of an atomic equivalent of tungsten is 110.4 parts by weight and six-tenths of an atomic equivalent of molybdenum is 57.6 parts by weight. Again one and four-tenths of an atomic equivalent of tungsten is 257.6 parts by weight and one and four-tenths of an atomic equivalent of molybdenum is 134.4 parts by weight.

In the case of the carbide one and four-tenths of a molecular equivalent of tantalum carbide is 270 parts by weight, while six-tenths of a molecular equivalent of tantalum carbide is 115.8 parts by weight.

Thus a composition totaling 380.4 parts by weight made up of 110.4 parts by weight of tungsten and 270 parts by weight of tantalum carbide would contain twenty-nine percent of tungsten and seventy-one percent of tantalum carbide. And again a composition totaling 373.4 parts by weight made up of 257.6 parts by weight of tungsten and 115.8 parts by weight of tantalum carbide would contain sixty-nine percent of tungsten and thirty-one percent of tantalum carbide.

If the tungsten be replaced by molybdenum then in the case of the composition having six-tenths of an atomic equivalent of tungsten or its equivalent in the form of molybdenum the parts by weight of molybdenum would be 57.6, which is the equivalent of 110.4 parts by weight of tungsten, which with 270 parts by weight of tantalum carbide

makes a total of 327.6 parts by weight, of which the molybdenum is approximately seventeen and one-half percent and the tantalum carbide eighty-two and one-half percent.

And again in the case where one and four-tenths of an atomic equivalent of molybdenum is substituted for a like atomic equivalent of tungsten, the molybdenum is present in 134.4 parts by weight with 115.8 parts by weight of tantalum carbide, making a total of 250.2 parts by weight of which the molybdenum is approximately fifty-three and three-quarters percent and the tantalum carbide forty-six and one quarter percent.

I prefer to use a mono-carbide but a small variation of say 20% in the carbon content of the carbide is not fatal to the production of a useful composition although the best composition corresponds closely to the formulæ of mono-carbide.

The difference between my composition and a fused alloy, is seen by the fact that a fused alloy of say 50% tungsten, 3% carbon, and the remainder tantalum, is brittle and worthless as a metal-cutting tool, while metal prepared according to my invention containing 50% W and 50% of TaC, resulting in an average carbon content of over 3% is strong and tough enough that it may be given a lipped or cupped cutting edge so as to curl the chip, a thing impossible heretofore with my steel-cutting composition.

In the cast alloy, for instance as described in British Patent No. 270,640 by Alfred Kropf a carbon content of only .70% is advised, (page 1, line 41).

Likewise when I have melted pieces of my composition, the resulting alloy is brittle and worthless for steel cutting tools. This shows that my composition cannot be formed by the melting process.

Instead of employing the carbide of one metal I may employ the carbides of any two or all of the metals of the group. The carbides of the metals such as vanadium carbide I have prepared by heating the pentoxide intimately mixed with carbon, in suitable proportions in graphite crucibles at about 1900° C. in the absence of air, although known ways of preparing the carbides such as heating the oxides with ethane or other carbon containing gases may be used. For a mixture of tantalum and columbium oxides, about 90% Ta₂O₅ and 10% Cb₂O₅, I use 22½% of its weight of carbon black which produces a carbide about 6.4% C. The presence of small amounts of sodium silicate, etc. in the initial oxide is beneficial rather than harmful, as they vaporize out of the product with a fluxing or cleansing effect. The fluffy physical condition of the tantalum or other carbide is helpful, and the tungsten metal powder should be of a high purity and finely divided.

As an example I take 50% by weight of tungsten metal powder, and 50% of tantalum and columbium carbide mixture, containing about 5% of CbC and 95% of TaC, running about 6.4% C and intimately mix these in a ball mill, by grinding for several days.

This very fine powder placed in the sparking chamber and treated for forty-seven minutes at 5 kva. with induced high frequency eddy currents of 7700 volts, and pressure of 4000 pounds per square inch results in a bit of metal composition which possesses the remarkable steel-cutting qualities desired in the commercial machining of steel. Such a product analyzes about 3.1% C and can be tested on the ordinary Rockwell diamond point hardness tester with 150 kg. load as used in testing hard steel.

This test, in the case of other forms of hard compositions, if a 150 kg. load be imposed on the penetrator will result in the penetrator being chipped and shattered and the impression will be irregular, which result is due to the great inequality in compression hardness between contiguous particles of the composition. 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, product of nickel and tantalum carbide the cementing metal has a very much lower compression hardness than the other ingredient which in the one composition is tungsten carbide and in the other composition is tantalum carbide.

In the case of my improved composition the compression hardness of both ingredients is very high and of substantial uniformity and thus the penetrator has no opportunity to slip or jump from a harder to a softer particle, and the impression is clean cut. The foregoing is proof of the superior toughness of my composition.

The same test is used in measuring the toughness of nitrided steel cases.

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.

What I claim is:—

1. A material for cutting-tools, dies and the like, in which the particles are in welded relation to each other and which comprises a composition of from approximately seventeen and one-half percent to sixty-nine percent by weight of a metal of a group composed of tungsten and molybdenum and from approximately eighty-two and one-half percent to thirty-one percent by weight of the carbide of a metal in the first column of the fifth group of Mendeleeff's periodic table.

2. A material for cutting-tools, dies and the like, in which the particles are in welded relation with each other and which comprises a composition of approximately from twenty-nine percent to sixty-nine percent by weight of tungsten metal and approximately from seventy-one percent to thirty-one percent by weight of tantalum carbide.

3. A material for cutting-tools, dies and the like, in which the particles are in welded relation with each other and which comprises approximately equal proportions by weight of a metal of a group composed of tungsten and molybdenum and of the carbide of a metal in the first column of the fifth group of Mendeleeff's periodic table.

4. A material for cutting-tools, dies and the like, in which the particles are in welded relation with each other and which comprises approximately equal proportions by weight of tungsten metal and tantalum carbide.

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

PHILIP M. McKENNA.