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HARD ALLOY

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This invention relates to hard compositions of matter or alloys and has for a general object the production and provision of a novel and an improved composition or alloy which is resistant to abrasion or wear, corrosion, and combined wear and corrosion, and which, among other uses, may be employed in wear and corrosion resisting parts, dies, and tools, for example, for turning or otherwise cutting metals.

For so much of the subject-matter herein disclosed which is also disclosed in our co-pending United States Letters Patent application entitled "Hard alloys" Serial No. 82,044, filed May 27, 1936, we claim the priority of said application.

Cast alloys suitable for tool materials have hitherto been classified as high speed steels and non-ferrous alloys. Usually such last mentioned alloys consist of a cobalt base, a metal of the sixth group of the periodic chart of the elements, and carbon.

Another object of the invention is to secure for a cast composition or alloy of that general class, a marked resistance to "cratering"; that is, the wearing away of tool material adjacent a working edge of a tool made of the alloy. Such cratering is particularly objectionable in such tools as milling cutters, where the grinding of the tool is done on an edge thereof and is exceedingly difficult to do on the face of the tool.

The carbides of the refractory metals of the fourth and fifth groups of the periodic chart of the elements are known to have extremely high melting temperatures, above 3,000 degrees centigrade. It is an object of the present invention to provide an alloy of the high speed class with an appreciable amount of one or more of the aforementioned carbides, especially tantalum carbide which can be made by casting.

A further object of the invention is the provision of an alloy or composition made by casting a molten mixture of a plurality of hard refractory metals from the fourth, fifth, and sixth groups of the periodic chart of the elements and/or the carbides thereof, and cobalt.

Other objects and advantages of our invention will appear more fully from the following description.

Illustrative of the invention, an alloy or a composition adapted to accomplish the foregoing objects has been made from the following elements in the indicated percentages by weight:

	Percent
Cobalt	38.7
Chromium	14.75
Tungsten	20.57
Tantalum	24.75
Carbon	1.23

To avoid the inconvenience of here reciting every specific variation which has been found to produce an alloy or product adapted to accomplish the objects of the invention, we are disclosing the following ranges of percentages which have been found to produce useful alloys or compositions in accordance with the invention:

	Per cent by weight
Cobalt	30 to 60
Chromium	5 to 30
Tungsten	15 to 50
Tantalum	10 to 50
Carbon	0.7 to 3

The invention is not limited to the specific elements mentioned above, but instead contemplates the use of from 30% to 60% by weight of one or more metals of the iron group including not only cobalt but also iron and nickel, the remainder of the alloy being a plurality of hard refractory metals from the fourth and/or fifth, and sixth groups of the periodic chart of the elements, and carbon or another metalloid such as silicon or boron, and in some cases nitrogen. Minor amounts of other elements, for example, manganese, may be present without injury to the desirable properties of our alloy.

In the foregoing examples, the carbon has been stated in terms of percentages by weight of all the alloy elements. It is probable that some, if not a major portion, of the carbon is in combi-

nation with the tantalum and the tungsten for the reason that both tantalum and tungsten are known to have a great affinity for carbon and for the further reason that the carbon is introduced in the alloy in the form of carbides of tungsten and/or tantalum. We do not, therefore, wish to limit our invention to the precise metallurgical structure of the alloy with reference to the allocation of the carbon. Instead, it should be understood that we contemplate the use of from 15% to 50% by weight of one or more tungsten group metals and/or their carbides, and from 10% to 50% by weight of one or more tantalum group metals and/or their carbides.

We have found, for example, that the tantalum and/or the tantalum carbide may be entirely or partially replaced by its molecular or volumetric equivalent of columbium from the tantalum or fifth group of the periodic chart of the elements and/or a carbide thereof, respectively, or by its molecular or volumetric equivalent of titanium or zirconium from the fourth group of the periodic chart of the elements and/or the carbides thereof, respectively. The tungsten and/or the tungsten carbide may be wholly or partially replaced by its molecular or volumetric equivalent of molybdenum from the sixth group of the periodic chart of the elements and/or a carbide thereof, respectively, in the alloy of the invention.

To illustrate such replacements and the introduction of carbon in the manner already described, some of the tantalum carbide in the first example shown hereinabove may be and has been partially replaced by the molecular equivalent of columbium carbide to give an alloy having the following percentages by weight of the indicated ingredients or constituents:

	Per cent
Cobalt	40
Chromium	15
Tungsten carbide	22.5
Tantalum carbide	18.68
Columbium carbide	3.82

To further illustrate such replacements, iron and nickel may be substituted for the cobalt; molybdenum may be substituted in part for tungsten, and columbium carbide may again partially replace tantalum carbide to give an alloy as follows:

	Per cent
Iron	49
Nickel	5
Chromium	8
Molybdenum	10
Tungsten	13
Tungsten carbide	5
Tantalum carbide	8.4
Columbium carbide	1.6

Thus it will be seen that some or all of the preferred elements and carbides may be replaced by the molecular equivalents by weight of the metals and carbides set out immediately above. In order, however, to avoid a long recitation of the specific examples illustrating such variations in constituents within the purview of the invention, we are disclosing below the molecular equivalents in terms of percentages by weight of the various metals disclosed above, as replacements for tantalum and that disclosed as a replacement for tungsten, which correspond to the ranges of tungsten and tantalum, respectively, as already disclosed:

From 15% to 50% by weight of tantalum is the molecular equivalent of:

From 7.69% to 25.68% of columbium by weight;
From 3.98% to 13.29% of titanium by weight;
From 7.52% to 25.12% of zirconium by weight.

From 15% to 50% by weight of tungsten is the molecular equivalent of from 7.83% to 26.25% of molybdenum by weight.

When the novel alloy is made with any of the replacements just disclosed above, the percentages of the other ingredients are varied substantially in accordance with the respective amounts of the replacements within the ranges shown above, it being our intention to keep the amounts of the carbides of the fifth and/or fourth groups, within the weight percentages shown above, constant by volume.

In producing the alloy of the invention as described above, the cobalt, or one or more metals of the iron group, are melted in a suitable crucible or container. The chromium or another hard refractory metal of the chromium group is then dissolved in the molten metal, after which a carbide of tungsten and/or its molecular equivalent by weight of molybdenum and the carbide of tantalum and/or its molecular equivalent by weight of columbium, zirconium and/or titanium are dissolved in the molten mixture of the sixth group metal and the one or more metals of the iron group. When the fusion of the foregoing constituents is complete, the alloy is cast by pouring it into suitable molds.

When the alloy of the invention is made as disclosed above, it may be employed as, for example, a tool, and such a tool will take a good cutting edge when it is ground. The novel tool so made has a strength as good or better than the non-ferrous cutting materials hereinabove referred to, has a hardness in excess of that of commercial high speed steel, and is remarkably free from cratering when used in turning or otherwise cutting steel. To illustrate we cite the following examples:

Example	Co	Carbides of Ta and/or Cb	W metal	WC	Cr	Mo	Hardness Rockwell A scale	Breaking strength, kilograms	C
	%	%	%	%	%	%			%
A	40	22.5		22.5	15		83.8	852	
B	40	22.5	19	3.5	15		83	1400	
C	50	22.5		5.7	11.4	10.4	80.1	1631	
D	45	15	12.5	10	17.5		82	1917	2

Examples A and B used as a turning tool cut the full length of a 31 inch long log of 1020 steel at a surface speed of 445 feet per minute, taking 0.016 inch depth of cut with a feed of 0.010 inch without showing any evidence of failure, or change in the appearance of the log. Under the same conditions, but using commercial tools of known non-ferrous alloys, the commercial tools exhibited intermittent brightening or glazing after a cutting distance of 19 inches.

The foregoing examples have also been subjected to uses involving wear and the corrosive action of hydrochloric and sulphuric acids and have shown marked superiority over other non-ferrous or high speed steel alloys. In one such use, the alloy composition C above, as a refrigerator shaft bearing where it was subjected to hydrochloric acid formed from the organic chloride used as the refrigerant showed clearly the suitability of our novel alloy for uses wherein

combined wear and corrosion are seriously limiting factors in the use of known alloys.

Attention has already been directed to the desirability of a tool material for use in the manufacture of the blades of milling cutters and similar tools where the grinding can be done only on the edge of the tool, and where cratering of the tool becomes a very serious objection. Tests of our novel alloy on cast iron indicate that it is as good or better than non-ferrous alloys in use, but that when turning steel it is much better than such non-ferrous alloys. It has a greater resistance to the heat developed in the tool with the result that higher speeds can be used in turning steel than can be used with high speed steel tools or tools of other non-ferrous alloys. Moreover, with the foregoing compositions, the melting temperature of our novel alloy is sufficiently low to facilitate melting and casting the same, and yet the alloy is remarkably hard, strong and tough.

Having thus described our invention in its present preferred form, we wish it expressly understood that it is not limited to the precise percentages and constituents specifically mentioned above, but that it is capable of changes within the scope of the appended claims.

What we therefore desire to claim and to secure by United States Letters Patent, is:

1. A cast alloy comprising from 30% to 60% by weight of one or more metals of the iron group, the remainder of the alloy being composed of from 5% to 30% by weight of chromium, from 15% to 50% by weight of a metal from the group composed of tungsten and molybdenum, and at least 10% carbide of a refractory metal of the fifth group of the periodic chart of the elements selected from the group composed of tantalum and columbium.

2. An alloy comprising from 30% to 60% by weight of metal of the iron group, the major part being cobalt, the remainder of the alloy being composed substantially of 5% to 30% by weight of chromium, and 15% to 50% by weight of a metal from the group composed of tungsten and molybdenum, and at least 10% of carbide of one or more of the metals of the group composed of tantalum and columbium.

3. A cast alloy comprising 40% by weight of cobalt, 15% by weight of chromium, 22.5% by weight of tungsten carbide, 18.68% by weight of tantalum carbide, and 3.82% by weight of columbium carbide.

4. A cast alloy made from 50% by weight of cobalt, 11.4% by weight of chromium, 5.7% by weight of tungsten carbide, 10.4% by weight of molybdenum metal, and 22.5% by weight of one or more carbides of metals from the group composed of tantalum and columbium.

5. A cast alloy comprising from 38% to 40%, by weight of cobalt; chromium in such percentage that its weight is more than one-third and less than one-half of the weight of the cobalt; tungsten in such percentage that its weight is greater than the weight of the chromium and less than the weight of the cobalt; one or both metals from the group consisting of tantalum and columbium in such percentage that the weight thereof is at least as great as the weight of the tungsten and less than the weight of the cobalt; and from 0.7 to 3% of carbon.

6. A cast alloy made from 45 per cent by weight of cobalt, 17½ per cent by weight of chromium, 10 per cent by weight of tungsten-carbide, 12½ per cent by weight of tungsten metal, 15 per cent by weight of one or more carbides of metals of the group composed of tantalum and columbium.

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