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ALLOY AND METHOD OF MAKING SAME

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This invention relates to new and useful alloys of hard metal. The object of the invention is to provide these alloys for various uses, but particularly for cutting tools. One of the main ideas is to make the new alloys in the form of cast metal and of such a composition that when formed into tools they will retain their superior physical properties under the most severe conditions as cutting tools, not only to withstand the action of cutting various metals in the ordinary way, but to withstand also the cutting of metal at higher operating temperatures than are generally feasible in cutting operations. Another idea is to provide high speed cutting tool alloys that are less expensive, but with higher efficiency, than those commonly used and now on the market for equivalent work.

I am aware that hard metal alloys are now available and used in tools where great hardness is desired. The alloys most commonly used for this purpose so far as I am aware are not made up as cast metal alloys but as a sintered product in which the metallic particles are in a sense cemented together rather than completely alloyed in a homogeneous mass. Although such sintered products do respond to the high tests for hardness, their particular structure, according to my observation, renders them less useful than where the alloy is made as a cast metal and which also responds to the desired hardness tests. I believe the reason for this fault in the commonly used alloys is due to the fact that in tool use the utility depends not only on the degree of hardness but to a large measure on the way the metallic structure of the composition is originally formed and the retention of that physical composition against the tendency to be detrimentally altered under severe use. There is not only the mechanical abrading action to be considered, but also under high temperatures there is the tendency of detrimental changes to take place in the alloy. But, when the crystalline structure of the alloy is originally formed as cast metal in a homogeneous mass it is of better structure for cutting tool purposes, the particles then being less liable to separate and less liable to fuse with the work being cut at high temperatures. These features need to be considered apart from the mere degree of hardness. It is the reason that I emphasize my alloys as made of cast hard metal which is one feature that characterizes the particular compositions of the new alloys.

My new alloys are made up according to the following compositions and have been found useful within the ranges of such compositions stated in terms of weight.

	% Composition range
Alloy #1:	
Molybdenum carbide (Mo_2C)	5–50
Iron (Fe)	30–65
Cobalt (Co)	10–30
Vanadium (V)	0.50–6.00
Alloy #2:	
Molybdenum carbide (Mo_2C)	5–50
Iron (Fe)	30–65
Cobalt (Co)	10–30
Vanadium (V)	0.50–6.00
Tantalum (Ta)	1.00–15.00
Alloy #3:	
Molybdenum carbide (Mo_2C)	5–50
Iron (Fe)	30–65
Cobalt (Co)	10–30
Vanadium (V)	0.50–6.00
Tantalum (Ta)	1.00–15.00
Titanium carbide (TiC)	0.20–10.00
Alloy #4:	
Molybdenum carbide (Mo_2C)	5–50
Iron (Fe)	30–65
Cobalt (Co)	10–30
Vanadium (V)	0.50–6.00
Tantalum carbide (TaC)	1.00–15.00
Alloy #5:	
Molybdenum carbide (Mo_2C)	5–50
Iron (Fe)	30–65
Cobalt (Co)	10–30
Vanadium (V)	0.50–6.00
Tantalum (Ta)	1.00–15.00
Titanium (Ti)	0.20–25.00

To make the compositions successfully one may proceed as follows: Molybdenum carbide powder, iron in powder form, cobalt in powder form, are mechanically mixed (for example in a ball mill) until the mixture is uniform. This mixture is then pressed into briquette form to facilitate melting and is then melted in a refractory container by suitable heating means. As the melt reaches liquid form, deoxidizing elements, such as aluminum and ferro manganese, in very small percentages, are added as scavengers, according to known deoxidizing methods and the small amount of impurities collect as slag on top of the melt.

When complete solution of the molybdenum carbide, iron, and cobalt is obtained in the melt, vanadium is added in the form of lumps of ferro vanadium. The percentage of iron in powder form first put in the mix is adjusted so as to give the desired percentage of iron in the alloy when added to the percentage of iron finally put in with the ferro vanadium.

The above procedure results in obtaining the alloy listed above as number one in the table, and can be obtained in a rather wide composition range as therein indicated. In my experience the

best results have been obtained with substantially the following specific percentages of the following substances—a particular molybdenum carbide, namely Mo_2C, 27%; cobalt 18%; vanadium 3.75%; and the remainder iron.

Such an alloy is preferably cast in semi-fabricated form for tool use. It responds to age-hardening treatment by a simple drawing procedure consisting of heating the cast forms for a suitable period of time, at temperatures ranging from 600° to 1100° centigrade, and cooling either in air or a controlled atmosphere.

From the composition shown in Alloy #2 of the above table, it is seen that it is like Alloy #1 except for the addition of tantalum. This addition gives the Alloy #2 greater resistance to chip abrasion. To get the tantalum in the alloy I have proceeded as in making Alloy #1 and added to the melt tantalum metal as a diffusion alloy, consisting of tantalum previously diffused with cobalt in a manner to be later described. Of course, the percentages of the other constituents are adjusted to accommodate the addition of the tantalum. I have found that tantalum added in either about 1½% proportion or in about 10% gives superior results to other percentages in the 1.00–15.00 range stated. Many experiments have indicated, however, that the alloy is particularly useful with its constituents arranged within the ranges stated.

From the composition shown in Alloy #3 of the above table, it is seen that it is like Alloy #2 except that titanium carbide is added. It is added to the melt as a combined diffusion of cobalt, tantalum, and titanium carbide in lump form and increases the hardness and rupture strength. Within the range stated in the table my experiments show that the preferred amount of titanium carbide is five-tenths of one per cent.

From the composition shown in Alloy #4 of the above table, it is seen that it is like Alloy #2 except that tantalum carbide is used instead of tantalum. In this alloy within the range stated it is desirable to get as much tantalum carbide in the melt as possible. This depends somewhat on the degree of heat used and the proportion chosen for the other constituents. The tantalum carbide is added to the melt as a diffusion alloy of tantalum carbide and cobalt.

Alloy #5 set out in the above table is like Alloy #2 except that titanium is added to the melt in the form of ferro-titanium alloys of a commercial grade.

The method of preparing the diffusion alloy constituents, where referred to above, is as follows: The titanium carbide, tantalum carbide, and tantalum metal (all in powder form—300 mesh) are individually or collectively mechanically mixed with cobalt metal powder in a range of ratios of the above mentioned constituents not exceeding 30% of the TiC, TaC, and Ta powders. The resultant prepared mixtures are cold pressed into briquettes, placed in a refractory boat, and fired in a hydrocarbon atmosphere through a suitable time and temperature cycle for complete diffusion. This procedure is followed to obtain complete solution of the above mentioned constituents in the desired cast alloy. The diffused alloy compositions as above prepared are cut up into small sections to facilitate adding to the final melt in the desired proportions in making the desired alloys previously described.

In making such alloys it will be noted that the total content of iron is the arithmetical sum of the iron originally mixed with molybdenum carbide and the iron content in the various ferro alloys added later; and that the total content of cobalt is the arithmetical sum of the cobalt originally added with the mechanical mixture prior to melting plus the cobalt contained in the cobalt diffusion alloys, added in lump form after the melting of the alloy has taken place.

The temperature of the melt is increased after the addition of the above named alloy constituents until complete solution takes place. During the process of melting, small additional percentages of the deoxidizing elements, previously mentioned, are added. In each alloy the final constituent added is the ferro vanadium.

After complete solution of all constituents, the melt is cast into suitable molds and allowed to cool. The cast material is then fabricated into desired shapes. The alloys, as cast, may be used in this condition, and when allowed to undergo work hardening from severe use their hardness and toughness will be increased appreciably. But these alloys respond to heat treatment which will insure increased hardness and toughness. And one feature of my invention is the production of the alloys as described, which alloys, in addition to their other advantages, will respond to age-hardening by a simple drawing procedure consisting of heating the fabricated shapes over a period of time, depending on their bulk, at temperatures ranging from 600° to 1100° centigrade, and cooling in air or a controlled atmosphere.

Having described my invention what I claim is:

1. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture, and when the mixture is in complete solution adding the vanadium content in the form of ferro vanadium and a titanium content of from .20 to 25.00 per cent. by weight in the form of ferro titanium and melting the whole for the cast metal alloy.

2. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture and when the mixture is in complete solution adding the vanadium content in the form of ferro vanadium and a tantalum content of from 1.00 to 15.00 per cent. by weight, consisting of tantalum previously diffused with cobalt and melting the whole for the cast metal alloy.

3. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture and when the mixture is in complete solution adding the vanadium content in the form of ferro vanadium, and a tantalum content of from 1.00 to 15.00 per cent. by weight and a titanium carbide content of from .20 to 10.00 per cent. by weight consisting of tantalum and titanium carbide previously diffused with cobalt, and melting the whole for the cast metal alloy.

4. The method of making a hard metal carbide alloy including iron, cobalt, and vanadium which comprises mixing mechanically with iron and cobalt in powder form a previously prepared stable carbide of molybdenum of the composition Mo_2C also in powder form, melting such mixture, and when the mixture is in complete solu-

tion adding the vanadium content in the form of ferro vanadium.

5. A cast metal carbide alloy comprising by weight molybdenum carbide Mo_2C about 27 per cent, cobalt about 18 per cent, vanadium about 3.75 percent, and the remainder iron.

6. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture, and adding to the melt vanadium in the form of ferro vanadium.

7. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture, and adding to the melt vanadium in the form of ferro vanadium and tantalum previously diffused with cobalt.

8. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture, and adding to the melt vanadium in the form of ferro vanadium and tantalum and titanium carbide previously diffused with cobalt.

9. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture, and adding vanadium and tantalum to the melt.

10. The method of making a cast metal carbide alloy of the kind described which consists in mixing molybdenum carbide powder, iron powder, and cobalt powder mechanically until homogeneous, melting the mixture, and adding to the melt vanadium, tantalum, and titanium carbide.

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