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METAL ALLOY

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The present invention relates to a novel process of making extremely hard carbide-containing alloys of definite compositions which are particularly adapted for use in the manufacture of high speed cutting tools or implements subject to abrasion, although such alloys may be used for various other purposes. In addition, the present invention discloses several specific alloys which give excellent results when made according to the present process.

In my co-pending application Serial No. 692,223 filed October 4, 1933, which is a continuation-in-part of application Serial No. 448,433 filed April 29th, 1930, and which in turn is a division of Serial No. 81,085 filed January 13, 1926, I have described alloys using a metal of the chromium group in combination with carbon, and containing one or more metals of the iron group.

The present application is a continuation-in-part of application Serial No. 407,296, filed November 14, 1929, which application is a continuation-in-part of my applications Serial No. 81,085 filed January 13, 1926, Serial No. 448,433 filed April 29, 1930, and Serial No. 405,540, filed November 7, 1929.

An object of the present invention is to provide a novel process for the production of carbide-containing alloys having suitable hardness, toughness and red-hardness to enable tools made therefrom to cut other metals at high speeds.

Further objects and advantages of the present invention will be apparent to those skilled in the art, from the following description thereof which sets forth in detail proved combinations of ingredients embodying my invention, which combinations of ingredients constitute several of the various forms in which the process of the invention may be used.

The process of the present invention involves the use of a preformed hard component, such as a carbide or carbide alloy. The preformed hard component is then mixed with a fused bath of matrix forming metal, that is, the carbide or carbide alloy—in the form of small particles or powder, or pressed slugs thereof—is mixed with the fused matrix forming bath and then cooled, as by casting, to obtain the carbide carried in a matrix material. It should be noted that carbide must be retained in the cast composition, that is, the carbide is not melted as is the usual procedure. Therefore, the carbide is sintered, that is, the carbide is heated and cooled in association with the molten bath, not melted. The cast compositions are therefore novel in that they contain a sintered hard constituent such as a sintered carbide or sintered carbide alloy. The cast compositions are not only harder but considerably tougher than alloys made in the usual manner, such properties being due to the fact that the carbide has not been precipitated from a molten condition, but has been retained in a sintered condition.

The process may comprise mixing particles of a hard component with a molten bath and casting to obtain a body of approximately the desired size and shape, such as a cutting tool, containing the sintered hard constituent. For example, particles of a carbide of metal of the chromium group may be mixed with a molten bath of one or more metals of the iron group, preferably iron or cobalt or both, and then cast in association with the molten constituent to obtain a cutting tool or body of approximately the desired size and shape containing sintered carbide of metal of the chromium group. In this case, for best results, the percentage of say tungsten carbide of the formula WC should be about 40% or more, usually not more than about 65%. An added feature of such compositions containing sintered components, as compared with other hard compositions, is that they respond to heat treatment if properly made, that is, the hardness may be varied by further subjecting the cast or cooled composition to a temperature below the melting point of the composition, the temperature varying according to the hardness and other properties desired, and being preferably between 1100° F. and a temperature just below the melting point of the composition. There is a distinction between the hardness so produced and the usual hardening of say high speed steel. In the case of high speed steel, the hardness produced might be termed a reversible hardness in that the steel may be hardened and annealed as many times as desired. The hardness produced by heating a cast composition containing a sintered hard constituent however may be termed an irreversible hardness, because, if the composition containing the sintered hard constituent is heated for a sufficient length of time at a temperature near the melting point, the hardness so produced is a permanent hardness and the composition cannot be returned to a condition such as existed before such heat treatment.

Compositions of greater hardness are obtained where the hard component is sintered in association with a molten bath containing not only metal of the iron group but also the metal or metals of the hard component. For example, if it is desired to make a cast composition containing sintered tungsten carbide, having the formula

WC, the tungsten carbide is preferably sintered in association with a molten bath containing not only metal of the iron group, but also tungsten. To obtain best results the tungsten should comprise at least 30% to 35% of the molten bath, although it may be considerably higher, or about 45% of the molten bath. The molten bath may also contain some carbon, but the carbon should not be present to the extent that the matrix material would be of insufficient strength or possess undesirable properties. Where the carbide is sintered in association with such a molten alloy bath, the percentage of sintered carbide may be somewhat lower than in the case of only iron group metal and may be as low as about 20% to 25%. The fact that the molten bath contains the metal of the carbide in sufficient quantity makes the sintered condition of the carbide more easily attained.

Compositions containing chromium, carbon and tungsten, chromium, carbon and molybdenum, or chromium, carbon and both tungsten and molybdenum have been found particularly adapted as hard components, although they are useful in themselves for some purposes. The following analyses give typical examples of such alloys.

Chromium	Carbon	Tungsten and/or molybdenum, cobalt, etc., and impurities
42.50	8.10	49.40
33.76	5.85	60.39
21.24	3.64	75.12
65.23	5.62	29.15
75.06	12.32	12.62

It will be seen from the analyses that the carbon varies from about three percent to 12½ percent. The chromium may likewise be varied from as low as 10 percent to as high as 75 percent, while the tungsten or molybdenum or both may likewise be varied from 20 percent to nearly 90 percent. The carbon content is greater with high chromium content inasmuch as the maximum amount of carbon which can be dissolved in and/or combined with tungsten without forming graphite is less than the amount of carbon which can be dissolved in and/or combined with chromium without forming graphite.

In making such alloys, particularly where high carbon contents are employed, it is preferable to use the elements in the powdered form, and to mix them together in the desired proportions and then to press slugs of the mixed powders, a suitable binding material being added to hold the powders in shape, if desired. The pressed slugs are then heated to an elevated temperature or sintered to form the hard component. The alloys may also be made by using the metallic carbides, such as exist in the final alloys, in powdered form. Where this is done, the carbides are formed separately, powdered to suitable fineness, mechanically mixed by themselves or with chromium, tungsten, carbon, or powdered alloys thereof, and then heated or sintered to form the final alloy.

In alloys of the present type, it is to be understood, of course, that the usual impurities are present; that is, that there may be small quantities of other metals such as iron, or the like, and also that special elements such as titanium, zirconium, tantalum, and the like, may be added in small quantities to give special properties to the alloys, and that where such special elements are added they are in such small quantities that the main alloy is always substantially a carbide composition containing chromium, carbon and one or more of the other metals of the chromium group. Cobalt, or one or more of the metals of the iron group may be present up to 10 percent, but where present, must be held low enough not to affect the carbide formation of the alloy. These alloys, which are essentially carbide alloys, that is, the alloy is essentially composed of carbides of the metals present, are particularly adapted for mixing with other alloys to produce final alloys of definite compositions.

As will be evident from the previous description, it has been found that where a carbide or carbide alloy is mixed and sintered in association with a second molten alloy, that excellent results are obtained where the second alloy contains the metal or metals of the carbide or carbide alloy, as well as metals of a different group. If a straight metallic carbide is used, such as either chromium or tungsten carbide, it may advantageously be used with a molten alloy containing the metal of the carbide and another metal.

Thus the above described alloys or hard components are preferably mixed and sintered with matrix forming alloys which should contain the metal or metals of the essential carbide or carbides of the hard component together with a metal or metals of another group, preferably metals of the iron group such as cobalt, the matrix forming alloy may contain carbon as well, but preferably an insufficient amount of carbon to have a particularly high carbide content. The following examples are given:

Hard component		*Matrix component*	
Carbon	8.5–9.0	Chromium	24–28
Chromium	55.0–60.00	Tungsten	12–18
Tungsten and impurities	32.0–36.00	Cobalt	64–54
		Carbide	low

Composition limits of final alloy

Carbon	3½–9	
Chromium	38–58	
Tungsten and Cobalt	balance	not less than 15%; not less than 5%

Hard component		*Matrix component*	
Chromium	12½–15	Chromium	7–8
Tungsten	75–80	Tungsten	38–42
Carbon	6½–7	Cobalt and impurities	balance

Final alloy limits of composition

Carbon	1–7
Chromium	7½–15
Cobalt	Not less than 5%
Tungsten	Not less than 38%

The preformed hard component, of the above examples, is mixed—in the form of small particles or powder—with a molten bath of the matrix alloy, the hard component being sintered in association with the molten matrix material so as to produce on cooling, as by casting, particles of the hard component carried in a matrix material. The particles or powder of the preformed hard component may be pressed in compact forms, such as slugs, before being mixed with the molten bath. Since it is not desirable to compress the powder or particles too strongly, but at the same time have a material which can be readily handled, a temporary binder such as an organic binder may be used to strengthen the pressed bodies.

The sintered hard component will ordinarily, be from about 20% to about 65% of the entire composition, although a lower limit might be used when casting bodies of small cross-section. However, when the process is used to provide a com-

position suitable for use with the process described in my application Serial No. 405,540, filed November 7, 1929, the hard component may be present in even greater quantity. In this case, a composition is prepared according to the present process and the composition thus prepared is powdered, pressed and sintered to form a rigid body of any desired size and shape.

The above hard and matrix components may also be preformed separately, each powdered to suitable fineness, the powders mixed in desired proportions, and the powder mixture may then be pressed and sintered to a rigid body of desired size and shape.

Where a matrix alloy, in the solidified condition, contains of itself a considerable amount of carbide best results appear to be obtained by sintering therewith a carbide or carbide alloy containing the same elements or the same carbide, as are present in the carbide of the matrix alloy.

The following example is given:

Hard component	Percent	*Matrix component*	Percent
Chromium	48.6	Chromium	50.06
Carbon	8.21	Carbon	8.29
Tungsten and impurities	43.19	Cobalt and impurities	41.65

The above components may be mixed and the hard component sintered in association with a molten bath of the matrix component. However, as an object of the process is to obtain the carbide in a sintered condition thus obtaining an improvement in the strength and hardness of the final alloy, the results obtained, using a matrix material which already contains a rather high percentage of carbide, are inferior to the foregoing examples. The process, however, provides a means of increasing the hardness of such matrix components in a beneficial manner.

Other modes of applying the principle of my invention may be employed instead of the one explained, change being made as regards the process herein disclosed or the materials employed in carrying out the process, provided the steps or step stated by any of the following claims or the equivalent of such stated step or steps be employed.

I therefore particularly point out and distinctly claim as my invention:

1. A sintered alloy comprising chromium 12.5% to 15.0%, tungsten 75% to 80%, and carbon 6.5% to 7.0%.

2. An alloy comprising chromium 12.5% to 15.0%, tungsten 75% to 80%, and carbon 6.5% to 7.0%.

3. A cutting tool containing a sintered alloy comprising chromium 12.5% to 15.0%, tungsten 75% to 80%, and carbon 6.5% to 7.0%.

4. A cutting tool containing an alloy comprising chromium 12.5% to 15.0%, tungsten 75% to 80%, and carbon 6.5% to 7.0%.

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