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ALLOY.

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This invention relates to alloys, more particularly those designed for use in the production of high speed cutting tools.

This application is a continuation in part of my applications Serial No. 493,108, filed August 17, 1921, and Serial No. 628,801, filed March 22, 1923.

It is necessary that alloys for such purposes have the property of "red-hardness" so that a tool made therefrom may maintain its cutting edge after the same has become red hot.

In addition to heat resistance, the alloy must also possess abrasive hardness and for this purpose should contain embedded in the metallic matrix hard crystals, usually metallic carbides.

Alloys of this general character are known comprising cobalt, chromium and tungsten. Both chromium and tungsten form carbides and of these the harder is tungsten carbide, so that the chief function of the tungsten is to give the alloy abrasive hardness.

While tungsten will give alloys abrasive hardness, the use of tungsten is attended with certain disadvantages not possessed by other metals.

Thus the melting point of tungsten is excessively high being over 3000° C. so that alloys thereof have to be made by dissolving the tungsten in the other molten constituents, like sugar dissolves in water, instead of by the admixture and mingling of molten tungsten with the other molten metals.

This renders the production of a homogeneous alloy more difficult. The temperature of formation of an alloy having large proportions of tungsten is also higher than is required to produce alloys of more easily fusible metals.

Further, the very high specific gravity of tungsten (18.7) as compared with that of nickel or cobalt (8.7) or chromium (6.9) tends to produce segregation of the constituents of the alloy and hinders the production of a homogeneous alloy.

Moreover, the amount of tungsten required to give the desired degree of abrasive hardness is higher than those of certain other metals.

The object of the present invention, therefore, is to provide an alloy containing a metal having the properties of nickel and cobalt, and a metal capable of forming a hard carbide and having a lower melting point than tungsten.

Another object of the invention is to provide an alloy in which the desired abrasive hardness is produced by a smaller proportion of the hardening metal than is possible with tungsten.

Other and further important objects of the invention will hereinafter appear.

All of these three metals form hard carbides, thus titanium carbide is harder than carborundum and will even scratch or score diamond.

These metals may be alloyed with cobalt and a small amount of carbon without substantial amounts of other metals. It is preferred, however, to employ either or both nickel and chromium in addition thereto.

While vanadium and chromium, for example, are similar in properties in so far as they both form hard carbides, the hardening effect of vanadium is much greater than that of chromium. The latter metal has a valuable toughening effect so that to obtain the best results the individual characteristics of these metals should be blended.

The same is true of nickel and cobalt. Alloys with nickel alone have a tendency to be "hot-short" while the cobalt alloys tend to be "cold-short". A combination of the two metals gives an alloy having the desired toughness and strength under all conditions.

The chief function of the cobalt and nickel appears to be that of producing a strong, tough, heat resisting matrix for the carbides of the chromium group or other group of metals. Neither cobalt or nickel possess the affinity for carbon, that is possessed by chromium or vanadium for example, so that it is probable that there is little or no carbide of either cobalt or nickel in my alloys.

The amount of carbon by weight in my alloys is comparatively slight, say 1.50%, but the proportion of carbide by volume may be over 10% of the entire alloy. This follows from the great differences in specific gravity of carbon and the metals with which it combines to form carbide. In view of this large content of non-metallic compounds, the composition of the matrix is of great importance.

Ordinarily alloys made in accordance with this invention will consist of cobalt, nickel, chromium and either titanium, vana-

dium or niobium with a small amount of carbon.

The percentage of these metals will usually be within the following limits:

	Per cent.
Cobalt	25 to 50
Nickel	10 to 20
Chromium	25 to 40
Vanadium, etc	10 to 25

The total amount of cobalt and nickel should be between 35 and 65%.

In certain cases a wider range of proportions may be employed such as those lying within the following percentages:

	Per cent.
Cobalt	15 to 55
Nickel	7 to 30
Chromium	20 to 45
Vanadium, etc	4 to 30

The total amount of cobalt and nickel should be between 30 and 70%.

As an example of a suitable alloy falling within the above limits the following may be given:

	Per cent.
Cobalt	37
Nickel	15
Chromium	36
Vanadium, etc	12

If the content of nickel is increased there should be a corresponding increase in the vanadium to maintain the desired hardness. This is exemplified by the following:

	Per cent.
Cobalt	21
Nickel	28
Chromium	25
Vanadium	26

In some alloys the chromium may be omitted—thus:

	Per cent.
Cobalt	40
Nickel	30
Vanadium	30

Further it may be found desirable to use only cobalt and vanadium as in the following alloy:

	Per cent.
Cobalt	75
Vanadium	25

In addition to the metallic constituents mentioned above a hardening element should be added. Usually this will be carbon although other elements, more particularly silicon, have a hardening effect. Many metallic silicides are as hard if not harder than the corresponding carbides.

These carbides are soluble to a certain extent in the molten alloy so that, unless the carbon content exceeds certain limits depending upon the nature and proportions of the metals forming the alloy, the latter on cooling will not contain free carbide crystals but only carbide in solid solution. While carbide in solid solution has a hardening effect it is not the desired abrasive hardness which results from the presence of free carbide crystals. The carbon content of the alloy should, therefore, be high enough to provide a substantial proportion of free carbide crystals in the alloy.

If the carbon is too high the alloy will contain in addition to carbide free uncombined carbon in graphitic form. As a given amount of carbon will combine with different weights of different metals to form carbides the amount of carbon which may be added before free graphitic carbon is formed in the alloy will depend upon the nature and proportions of the metals composing the alloy.

Usually the amount of carbon in the alloy will be between 1 and 2.5%, for example around 1.5%, although in some cases it may be as low as 0.5 or as high as 3.5%. It is desirable on the one hand to have enough carbon to produce free carbide crystals and on the other hand not enough to cause the formation of particles of graphitic carbon throughout the alloy, as the presence of graphitic carbon greatly reduces the strength of the alloy.

The carbon is most readily and accurately added as a carbide, such as the carbide of one of the metals forming the alloy as chromium.

In addition to a hardening element it is frequently advisable to use a de-oxidizer such as aluminum or boron. Further, the hardening element and de-oxidizer may to advantage be added simultaneously in the form of boron carbide.

While my alloys consist essentially of the above metallic and non-metallic ingredients it will be understood that the addition or presence as impurities of small quantities of other metals, etc., such as iron, manganese or the like, will not change the general characteristics of my alloys.

In the process of forming the alloy the several ingredients in proper proportion are placed in a crucible preferably together with some readily fusible material, such as glass, which will form a protecting layer over the alloy and so prevent oxidation.

The temperature employed for fusing the constituents may be from 1750° to 1950° C., according to conditions. As these alloys do not respond to heat treatment, as does steel, at least at a temperature below 1100° C., the alloy must be formed into the desired shape by casting and then grinding instead of by forging.

To obtain the best results molds made of sand should not be employed since, using such molds, even if brushed over with graphite powder, the bars are apt to be full of blow holes and too soft to make good lathe tools. Preferably the molds are con-

structed of graphite although cast iron may be used for this purpose if the surface is treated before use to prevent the hot metal adhering thereto. Such treatment may consist either in treatment with sulphuric acid or coating with carbon by the application of a smoky flame thereto.

Graphite is, however, much superior to cast iron as a material for molds. In the first place it is much easier to machine graphite than cast iron so that molds for casting special sizes and shapes can be more readily made. Then again, cast iron molds have to be repeatedly treated with sulphuric acid solution since the effect of the treatment soon wears off.

Further, cast iron molds, especially for small sizes of bars, chill the metal too rapidly. This chilling makes the bars hard, and, while hardness is a desideratum, it should be uniform throughout the bar and chilling makes the outer layers harder than the center.

Now graphite has a lower specific heat per unit volume and also a much lower heat conductivity than cast iron. Consequently the rate of abstraction of heat from the cooling metal is far less in the case of graphite than in the case of iron molds.

I have also found that the hardness of bars cast with the above alloys vary according to the rate at which they cool so that a small bar, which necessarily cools more rapidly than a large one, is, other conditions being the same, harder. On the other hand, increasing the carbon content of the alloy increases its hardness. It has further been found that heat treatment of the alloy after casting does not appreciably change its hardness so that the alloy may be termed "self-hardening".

To secure the best results it is necessary to hit the happy mean between too great hardness, which means brittleness, and liability to flake or chip, and too little hardness, which means that a tool made therefrom will be too soft to cut for the desired length of time or to cut hard metals.

This I accomplish by the present invention by varying the amount of hardening element, such as boron carbide, added with varying dimensions of the bar to be cast.

For example, for a ¼ inch bar 0.56% boron carbide may be used to advantage; for a ⅜ inch bar 0.85% and for a ½ inch bar 0.97%.

By so varying the content of boron carbide the sum of the hardness due to chilling and the hardness due to the hardening element is maintained substantially uniform irrespective of the size of the bar cast.

If on casting a trial bar from any given melt the alloy appears to be too soft, small additions of tungsten may be added to the crucible to give the requisite hardness.

The above mentioned quantities of carbon, added as boron carbide, are considerably lower than the desired carbon contents of the bars for the reason that not only do the constituent commercial metals contain small amounts of carbon but also larger amounts of carbon are picked up from the crucible in which the alloy is made, if an unlined graphide crucible be employed.

As a result of the picking up of carbon from the crucible it is desirable to avoid heating the metal to too high a temperature or for too long a time in the crucible. Further, when remelting scrap along with a proportion of new metal the quantity of boron carbide added should be decreased to allow for the carbon already in the scrap.

I am aware that the proportions of the constituents of the alloys and numerous details of the method of manufacture of such alloys and tools therefrom may be varied through a wide range without departing from the spirit of this invention, and I do not desire limiting the patent granted, otherwise than as necessitated by the prior art.

I claim as my invention:

1. An alloy comprising 15 to 55% cobalt, 7 to 30% nickel, 20 to 45% chromium and 4 to 30% of a metal not in the chromium group capable of forming a hard carbide and having a melting point between 1000° and 2100° C. with a small amount of carbon.

2. A high speed tool formed of a substantially non-ferrous alloy compring 15 to 55% cobalt, 7 to 30% nickel, 20 to 45% chromium and 4 to 30% of a metal not in the chromium group capable of forming a hard carbide and having a melting point between 1600° and 2100° C. with a small amount of carbon.

3. An alloy for high speed tools comprising 25 to 50% cobalt, 10 to 20% nickel, 25 to 40% chromium, 10 to 25% vanadium with a small amount of carbon.

4. An alloy for high speed tools comprising approximately 37% cobalt, 15% nickel, 36% chromium, 12% vanadium with a small amount of carbon.

In testimony whereof I have hereunto subscribed my name.

PERCY C. CHESTERFIELD.