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ALLOY

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My invention pertains to metals and alloys of the iron and chromium groups in association with previously unknown nitrogen compounds.

The subject matter of this application is a continuation in major part of my co-pending application of like title filed November 21, 1927, Serial No. 234,896.

The metals of the iron and chromium groups are known to have their characteristics measurably influenced by a carbon content, indeed, principally owing to the creation of varying amounts of carbide. Heretofore, such carbide formation has usually been commingled with the metals by crystallization, either during solidification of the metals from molten condition or by solution and solidifying stages as in a hardening process.

The control of the carbide production is of outstanding importance to the quality of the product in the case of many metals and alloys, notably for tool steels and cutting metals in consequence of many annoying influences and contingencies with which one is confronted and which are factors or determinants both of the quality and of the quantity of the hitherto ever desired carbide formation alike during solidification from molten form and during hardening procedures.

I avoid such influences and contingencies by not continuing to have the carbide production coincident to crystallization occurrences, but instead permit the carbide production to be necessarily influenced at the very least quantitatively during the manufacture of alloys.

Nitrogen has heretofore played an undesirable part in the production of and operation upon certain metals. As a gas it combines to a greater or less degree with molten metals and effort has been made to exclude it from the melt, for instance, by the use of elements like titanium which have an especially strong affinity for nitrogen.

According to the present invention, nitrogen is adapted to lend particular advantages to metals or alloys, contrary to previous supposition, provided it does not appear as an occluded gas, but instead appears in chemical combination as a definite metal nitride with the metals or alloys. Such metal nitrides, as those of the metals of the iron group and of the chromium group, readily combine with fluid metals and attain homogeneous solutions therewith. The physical characteristics of sundry metals are thereby improved in respect to toughness and hardness.

I have made the discovery that the nitrification is consummated with markedly greater facility and is also possible with such metals which heretofore resisted it, especially with all metals of the

iron group and of the chromium group, when the nitrification proceeding follows a superficial carburization or when a carburization occurs simultaneously with the nitrification.

I have also discovered that certain metals, especially those of the iron and chromium groups, may have the stated reactions increased if the nitrogen is joined with metal carburet compounds—with metal carbides—to appear in the form of metal carbo-nitrides. These compounds or combinations manifest an extraordinary hardness and when added to other metals, namely those of the iron and chromium groups effect an increased hardness thereof.

In alloys possessing high carbon content like cast iron, the presence of nitrides or carbo-nitrides achieves a promotion of graphite separation.

The described employment of metal nitrides and metal carbo-nitrides comprehends the result not only in association with melt-produced metals but their employment is quite as advantageously realized with metals or alloys which are obtained by sintering in pulverized condition in consequence of their high melting temperatures, as for example the common metal article composed of tungsten and molybdenum or their carbides for use as tools for cutting and shearing. By use of the nitrides or carbo-nitrides one is able to realize degrees of hardness which for practical purposes are little if at all inferior to that of the diamond. Such pieces can also be produced wholly or in preponderating part from nitrides or carbo-nitrides.

I realized my object of producing an alloy amazingly superior to any known or used by including metal-nitrides or metal carbo-nitrides as alloy components to achieve a commercially successful metal or alloy of the iron or chromium groups or both. It has been established that when prepared metal nitrides or metal carbo-nitrides of the iron group or of the chromium group or both are brought together with molten metals a remarkable stabilization ensues to achieve homogeneous solutions with the metals. When such solutions solidify the carbide production is no longer dependent upon the varying accidents or contingencies of crystallization, because from such homogeneous solutions the carbide can itself quantitatively crystallize.

These procedures are of particular importance to all those alloys of the iron group which contain metals of the chromium groups like alloy steel and especially the high productive steels having tungsten and molybdenum, or the common cutting steels having cobalt and nickel bases

and some chromium-tungsten and molybdenum. For example, if instead of adding tungsten as a metal to a molten alloy one supplies it in whole or in part as tungsten nitride or carbo-nitride, substantially better attributes later manifest themselves. In many instances it likewise proves advantageous to add the nitride or carbo-nitride not only to one, but to several components of the alloy, practically in the form of prepared complex nitrides, for example in the form of chromium-tungsten double nitrides or molybdenum-tungsten double nitrides. Also, it has been shown to be advantageous first to melt or to dissolve the distinct nitrides composing the double nitride and then to bring them into integral union before commingling with the metal bath.

I have further discovered that the metal nitrides exhibit a stability similar to that of the metal carbides in fluid alloys. By themselves such metal nitride combinations are known, especially their high degree of hardness. Heretofore, they have been utilized by superficial nitrification of metal articles by means of an external action of nitrogen. However, such performances have the disadvantage of a very thin nitrified coating which because of its brittleness is insufficiently tough for the mechanical requirements against impact or blow. Such a detriment is avoided according to this invention by having the metal nitrides as in the case of the carbides, attain a homogeneous solution through the entire cross-section of the piece produced.

For some productions, especially for those of greatest hardness, it has been determined to be particularly advantageous simultaneously to employ both the metal carbides and the metal nitrides as components. That can also be satisfactorily achieved by making both carbides and nitrides as integral units—metal-carbo-nitride so-to-speak, preparatory to their introduction in metal baths. Such a product may occur by melting or sintering the carbides and nitrides together or by nitrification of the carbides by means of nitrogen or nitrogen compounds.

The described employment of metal carbides and metal nitrides does not merely comprehend their addition to fluid metal melts, but may be employed equally well in the production of alloys which owing to their high melting points are achieved from powdered condition with the aid of compression or sintering, as for instance tools for cutting and shearing composed of tungsten or molybdenum or carbides thereof. In this manner grades of hardness are attained which are scarcely inferior to that of a diamond.

I have discovered that actions or effects, similar to those of the metal nitrides heretofore mentioned, are realized by employment of metalloids having metallic properties, like boron and silicon or even with titanium, hence with boron nitride, boron carbo-nitride and the analogous combinations of silicon and titanium. These nitrogen compounds likewise readily combine with most of the metals and form homogeneous solutions therewith.

This new alloy is composed of metal compounds which were hitherto unknown and evolved by me. The outstanding feature of this alloy is its exceptional resistance to wear, indeed, to such a degree as has heretofore been reckoned impossible in metals. This characteristic together with its great hardness makes possible an amplified range of employment of it on cutting tools, alike for metal working and for minerals and all hard materials.

In the field of metal working this alloy has already achieved revolutionary innovations. It is possible to attain so great a cutting speed with tools made of this alloy that the shavings are red hot during removal from the work piece. Notable reductions in the manufacturing costs throughout the entire machinery art are thereby attained, particularly also in the automobile industry. A further and surprising improvement in the metal working art was realized by reason of the possibility of operating with it without difficulty upon a series of the hardest and toughest metals which heretofore could not be worked at all or only by grinding. For example, manganese steel containing 12 to 14% manganese which is much used in the pulverization and mill industry and also elsewhere, could only be ground at high cost with carborundum discs upon special grinding machines. Using tools, tipped with this alloy, manganese steel may be turned on any ordinary lathe without difficulty and at a cutting speed of from forty to one hundred feet a minute and in one hour one obtains one hundred to two hundred pounds of chips. These surprising achievements will in the future assure substantial extension in the use of manganese steel because of the measurable simplification and cheapening of the fabrication costs.

It has been further established that my alloy will operate upon case-hardened metals and it has thereby gained for itself a wide field in the fabrication of rollers. The rollers for the manufacture of rolled iron, tubes, sheet metals and railroad rails were previously preferably ground or in part also turned with diamond or special steel; but that could occur only with a very low speed of about one to two feet a minute because of the great hardness of such chilled casting. The rollers therefor demanded very long working time and correspondingly high costs. As contradistinguished, this alloy permits an increase of from ten to fifteen times the previous cutting speeds and hence a corresponding cheapening of manufacture.

This alloy has earned a new usefulness because of its adaptability for work on steels in oil quenched or case-hardened condition and which, as is known, could heretofore only be ground. This is of special importance for the automobile industry which operates with large quantities of these materials.

My new product is especially adapted for all sorts of stone-drills, for stone crushers and in mines. Its performances are extraordinarily good on earth drilling machines in competition with diamond drill crowns which are not only considerably more expensive, but also perform less in drilling. My alloy furnishes considerable advantages for the tools of the marble industry.

Below are listed several repeated commercial performances of tools provided with this alloy. Cast iron—previously 60 to 80 feet a minute; with this alloy 250–300 feet a minute.

Steel—previously 120 feet a minute; with this alloy 400–500 feet a minute.

Tool steel—previously 30–40 feet a minute; with this alloy 150–250 feet a minute.

Manganese steel—heretofore only grindable; with this alloy 50–100 feet a minute.

Chrome-nickel-steel oil-quenched with 250,000 pounds to square inch tenacity) previously not possible to be machined; with this alloy 60–80 feet a minute.

Case-hardened (two oil-quenchings) only

grindable before; with this alloy machinable at 30 feet a minute.

Chilled rollers—previously 1-2 feet a minute; with this alloy 20-30 feet a minute.

5 The preceding list should be understood to set forth only a small comparative group. My alloy will perform better wherever great resistance to wear is required and is capable of successful employment where other marketed alloys are utterly
10 useless.

It is to be realized that the scope of my invention comprehends some changes in practising the method. The particular descriptions are merely specific exemplifications. For instance, I would
15 have it clearly understood that I realize that the scope of my invention need not be restricted to a metal or alloy solely adapted for cutting because its composition is known to be adapted also for fabricated steel; and that I further realize that
20 the metal nitrides or metal carbo-nitrides or both need not be previously prepared, but instead that such nitrogen compounds may be otherwise associated as, for example, by adding them to fluid metal.

25 If the alloy is to be manufactured from a sintered aggregate the homogeneous nitrogenization or azotization may be accomplished by exposure to dissociated nitrogen, simultaneously with or subsequently to carburization, either before or during
30 the sintering process, while the metal mass is still porous.

This alloy is produced with the aid of the method described and claimed in my Patent No. 1,803,276 of April 28, 1931.

35 I can usefully employ with my azotized tungsten carbide any one auxiliary metal from either the iron group or the chromium group, though for more restricted application than when employing metal from both groups or when employ-
40 ing three azotized metals including two from one of the stated groups. The type of alloy (cemented carbonaceous tungsten compound) remains the same—only the adaptability varies.

The generic idea is the improving use with
45 any carbonaceous and nitrified compound of a metal of the chromium group as a sintered alloy component—of auxiliary or cementation metal of lower melting temperature than the compound. The azotized carbonaceous compound (azotized
50 carbide or coined term carbonitride) is to constitute the principal proportion with the auxiliary metal varying rather widely, depending upon the intention of use for the product—
55 whether for dies, cutting tools, armoring or as jewel-pivot substitute. For instance, for measuring-instrument surfacing, a larger per cent of auxiliary metal is preferred in order to permit achieving a high and hence accurate surface
60 polish.

Manifestly to anyone skilled in this art, the larger the per cent of azotized tungsten carbide the more hard and gritty will be the resulting product; and the larger the per cent of auxiliary
65 metal the less hard, but the more tough will be the resulting product. Consequently, the proportions of the carbonaceous compound and of auxiliary metal may vary over a rather extended range, the desideratum being the proportionate

selection which test shall have established as best for any particular use. When the alloy comprises a very high per cent (80 to 90) of the carbonaceous compound it cannot be given the
5 high surface polish which is desirable, for instance for an armoring inlay on a measuring instrument. I have for years manufactured and sold alloys embodying my invention with a range
10 of variation of thirty-five per cent and over for the auxiliary metal. The toughening addition of more auxiliary metal than is feasible when, say, tungsten carbide alone is employed with cementation
15 metal of lower melting temperature, becomes feasible in consequence of the azotized feature of my invention. The nitrogen content varies somewhat according to the material and the time of exposure to dissociated nitrogen gas, but is always less than five per cent (5%) of the complete alloyed aggregate.

I furnish here below three exemplifying formulae of my invention.

	Per cent
1	
Azotized tungsten carbide-----	90
Tungsten -----	4
Cobalt-----	6

	Per cent
2	
Tungsten carbonitride-----	60
Chromium carbonitride-----	8
Cobalt-----	12
Tungsten -----	20

	Per cent
3	
Tungsten carbide-----	80
Azotized molybdenum carbide-----	12
Chromium -----	2
Nickel -----	6

I claim:—

1. A sintered alloy consisting of from about
45 fifty per cent to about ninety per cent of both a carbide and an azotized carbide of metal of the chromium group, a larger per cent of the former being used with a lesser per cent of the latter, and as remainder cementation metal of the iron or chromium group ranging from ten to forty-nine per cent.

2. A sintered alloy having from fifty to about
50 ninety per cent of azotized carbides of a plurality of metals of the chromium group and as remainder, from about forty-nine per cent to about ten per cent in the aggregate of metal both of the iron group and of the chromium group,
55 the relative percentages of the metal from the iron and chromium groups varying according to the metals of the chromium group which are selected for chemical combination as azotized carbide.

3. A sintered alloy comprising about ninety
60 per cent of a mixture of a carbonaceous tungsten compound and of an azotized carbide of a metal of the chromium group and as remainder metal from both the iron and chromium groups, said elemental metal being of lower melting temperature than said mixed compound for cementation
65 of the ingredients.

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