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PRODUCTION OF HEAVY METALS

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This invention relates to improvements in or relating to the production of heavy metals and articles produced therefrom.

It has already been proposed to provide a hard substance by combining hard metals such as carbides, silicides, nitrides and the like by sintering in the presence of metals of lower melting point in particular with a metal of the iron group. These latter metals, serving as auxiliary or binding metals, are on the one hand considerably softer than the hard substances and therefore influence unfavourably the desired hardness of the end-product, and on the other hand cause great difficulties during the step of attempting to mix the materials owing to the great difference in the specific weights of the ingredients, namely the hard metals and the auxiliary or binding metals, with the result that a uniform distribution of the binding agent among the hard substances is not achieved, such lack of uniformity being the reason for the frequent failure of hard metals produced by known processes and the crumbling up or rapid blunting of hard metal cutting-edges.

One of the objects of the present invention is to provide a simple and efficient method in which the end product is free from the above disadvantages in that the material is of uniform and homogeneous composition, further objects being to provide a material of great toughness and resistance to shock and one from which cutting tools having uniform and long life may be made.

It is a further object of the present invention, to provide a method of preparing hard metals or substances comprising mixed carbides, silicides, borides, nitrides or the like in which the ingredients serving to form the hard metals or substances with or without any additional substance or substances are first mixed together and then subjected to heat treatment whereby to produce said hard metal or substance. In this way the hard product upon its formation already incorporates the desired ingredients of the end product intimately and uniformly associated with one another and the necessity, present in known processes for treating the individual hard substances in order to obtain the desired mixed product is entirely avoided and a very tough and hard material results.

In carrying out the present invention the requisite amounts of the ingredients serving to form the desired hard metal may be employed alone or in some cases one or more free metals may also be added. Such free metal or metals may in fact be provided by employing an excess of one or more of the metals serving to form the desired hard metal and/or by adding one or more other metals having a lower melting point than that of the hard substance produced.

In order that the present invention may be well understood I will now describe by way of example some embodiments thereof.

1. In one example of a method of making a hard substance without additional metals, the metals serving to form the desired hard metal, e. g. mixed carbides, preferably after being very finely disintegrated, are mixed together then the requisite amount of carbon is added after which the ingredients are again thoroughly mixed and then subjected to heat treatment whereby to produce mixed carbides.

The metals employed consist, in this example, of tungsten, niobium and vanadium whereby a product of uniform hardness is obtained, one of such metals being present in an amount equal to twice the amount of either of the other two metals which are present in about equal proportions. Thus for instance the end product may be of about the following composition:

		Per cent
(I)	Tungsten carbide	55
	Niobium carbide	15–20
	Vanadium carbide	15–25
or		
(II)	Vanadium carbide	50
	Tungsten carbide	20–30
	Niobium carbide	20–30
or		
(III)	Niobium carbide	40
	Tungsten carbide	20–40
	Vanadium carbide	20–40

2. In an example involving the preparation of a product having a free content of one of the metals from which the hard metal is produced then as in the case of the earlier example the ingredients are first thoroughly mixed before being subjected to heat treatment for the production of a hard metal. Assuming that the hard metal is to be formed from tungsten, niobium and vanadium in this example and carbides are to be formed then an amount of carbon equivalent to the theoretical quantity necessary to convert the tungsten and niobium into carbides but only about 40–50% of the theoretical quantity necessary to convert the vanadium content into a carbide is added to such metals, the subsequent periods of heat treatment being carried out very slowly.

3. In an example involving the preparation of

a product having a free content of one of the metals from which the hard metal is produced and a very small amount of one or more additional metals with lower melting point or points than that of the hard substances, which product is suitable in cases where a hard metal of a specially tough nature is required, the procedure and ingredients according to Example 2 may be adopted subject to adding to, and mixing with, the starting materials a suitable metal of lower melting point. Such latter metal may for instance be nickel, only a very small amount of from 1% to 3.5% being required. In this example it is again desirable thoroughly to mix the metals together and then thoroughly to mix such metals with the required amount of carbon before carrying out the heat treatment.

4. In an example involving the preparation of a product consisting of a hard metal and an additional metal having a melting point lower than that of the hard metal, i. e., a hard metal of an already known kind as regards its constituents but prepared in a different manner in that all of the ingredients are mixed together prior to the formation of a hard metal, similar procedure to that described in the earlier examples is followed, the starting materials being so chosen however that the end product comprises about 90–98% individual hard substances or hard substance mixtures and 2–10% additional or auxiliary metals. Such additional or auxiliary metals may consist for instance of one or more of the following: cobalt, nickel, iron, manganese, chromium, titanium or a mixture of iron, manganese, chromium and nickel.

In all the above examples the mixtures may be subjected to heat treatment in any suitable furnace and the heat application is so controlled that the temperature is increased in steps determined by the temperatures at which the respective metals are converted into carbides. With mixtures of tungsten, niobium, vanadium and carbon, the formation of the individual carbides would normally take place more strongly as regards tungsten carbide at about 1450° C., as regards niobium carbide at about 1950° C., and as regards vanadium carbide at about 2200° C.

It has been found however, with great economic advantages, that in the production of mixed carbides in a manner according to the present invention those carbides which normally have relatively high formation temperatures can be produced at lower temperatures in the presence of other carbides having relative low formation temperatures. Thus for instance if tungsten and vanadium, which have relatively high carbide-forming temperatures, are converted into carbides by heat treatment of a mixture of tungsten, niobium, vanadium and carbon then carbides of niobium and vanadium can be formed at temperatures of 1600° C., and 1700° C., respectively. Under these circumstances therefore the aforesaid starting materials are slowly heated up to 1450° C., the most favorable temperature for the formation of tungsten carbide and this temperature is maintained for 30 to 45 minutes. The temperature is then increased to the temperature region of the formation of niobium carbide, i. e., about 1600° C., in the presence of the other ingredients in question, and this temperature is maintained for some time after which there is a further increase up to 1700° C. The last mentioned temperature is again to be maintained for some time, and after an interval of one hour heat application is gradually discontinued.

The so produced mass of mixed carbides is not yet of wholly uniform structure and in order to attain this optimum uniformity further heat treatment is applied. Prior to such treatment however the mass is disintegrated and the carbon content is checked. This content will in general be found to be satisfactory but if it should be too low then further preliminary heat treatment in the presence of carbon is carried out. Assuming that the carbon content is satisfactory or has been rendered satisfactory the mass is ground to a fine powder of an order of 10,000 per square centimetre. The powder is then formed into small platelets or into other desired shapes and then subjected to further heat treatment in a suitable furnace, such treatment being continued for several hours at a steady temperature of about 100° to 150° C. higher than the temperature attained during the previous heat treatment.

We claim:

1. A method of preparing hard metals and substances comprising mixed carbides, in which the ingredients serving to form said metals and substances are first mixed together and are then subjected to heat treatment at progressively increasing temperature in stages, the temperature stages corresponding to the temperatures at which the individual constituents most readily combine.

2. A method of preparing hard metals and substances comprising mixed carbides, in which the tungsten, vanadium, niobium and carbon, are first mixed together, one of said metals being present in an amount equal to twice the amount of either of the other two metals which are present in about equal quantities, and subsequently subjecting said mixed ingredients to heat treatment, said treatment being heat controlled so that the temperature is raised in steps with a soaking period between the steps, whereby to produce said hard metals and substances.

3. A method of preparing hard metals and substances comprising mixed carbides, in which tungsten, vanadium, niobium, and carbon are first mixed together with any other ingredients the quantity of carbon being sufficient to convert the whole of the tungsten and niobium contents into carbides but only about 40–50% of the theoretical quantity required to convert the vanadium content into vanadium carbide, said mixed ingredients being subsequently subjected to heat treatment, said heat treatment being controlled so that the temperature is raised in steps with a soaking period between the steps, and whereby to produce the said hard metals and substances.

4. A method of preparing hard metals and substances comprising mixed carbides, in which the ingredients serving to form said substances including tungsten, niobium, vanadium, and carbon are first mixed together in a finely divided state and are then subjected to progressively increasing temperature in stages with a soaking period between the stages whereby to produce said hard metals and substances, the temperature stages corresponding to the temperatures at which individual constituents most readily combine.

5. A method of preparing hard metals and substances comprising mixed carbides in which the ingredients serving to form said metals and substances including tungsten, vanadium, niobi-

um and carbon are first mixed together in such quantities that the end product comprises 55% tungsten carbide, 15–20% niobium carbide, 15–25% vanadium carbide, said ingredients being then subjected to heat treatment, said treatment being controlled so that the temperature is raised in steps with a soaking period between the steps, whereby to produce said metals and substances.

6. A method of preparing hard metals and substances comprising mixed carbides, in which the ingredients serving to form said metals and substances including tungsten, vanadium, niobium and carbon are first mixed together in such quantities that the product comprises 50% vanadium carbide, 20–30% tungsten carbide, and 20–30% niobium carbide, said mixed ingredients being subsequently subjected to heat treatment being controlled so that the temperature is raised in steps with a soaking period between the steps, and whereby to produce said metals and substances.

7. A method of preparing hard metals and substances comprising mixed carbides, in which the ingredients including tungsten, vanadium, niobium and carbon are first mixed together in such quantities that the end product comprises 40% niobium carbide, 20–40% tungsten carbide, 20–40% vanadium carbide, and are subsequently subjected to heat treatment being controlled so that the temperature is raised in steps with a soaking period between the steps, and whereby to produce said metals and substances.

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