Oct. 2, 1956 C. G. GOETZEL ET AL 2,765,227

TITANIUM CARBIDE COMPOSITE MATERIAL

Filed Dec. 16, 1950



Fig. 1

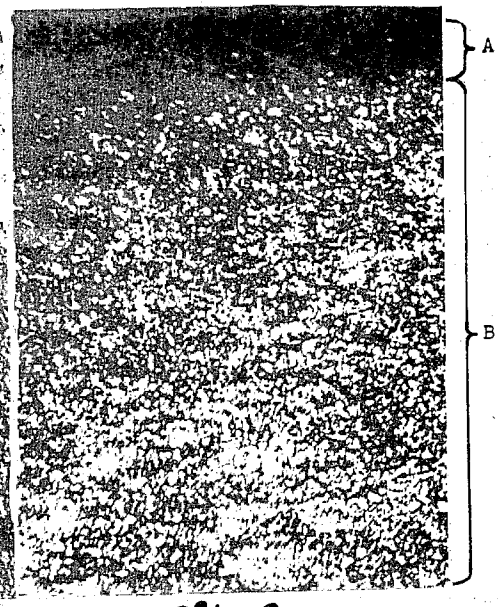


Fig. 2

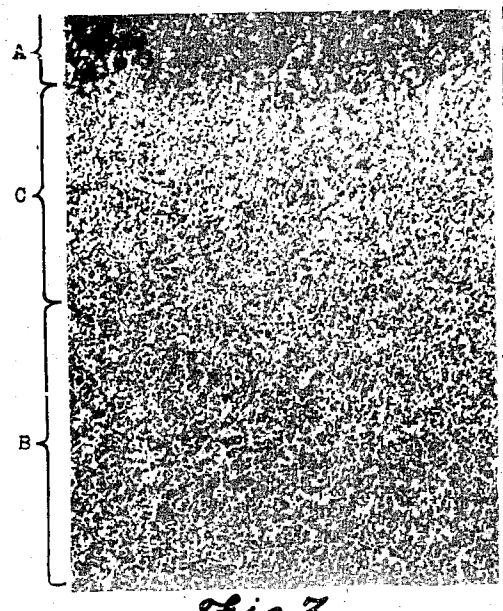


Fig. 3

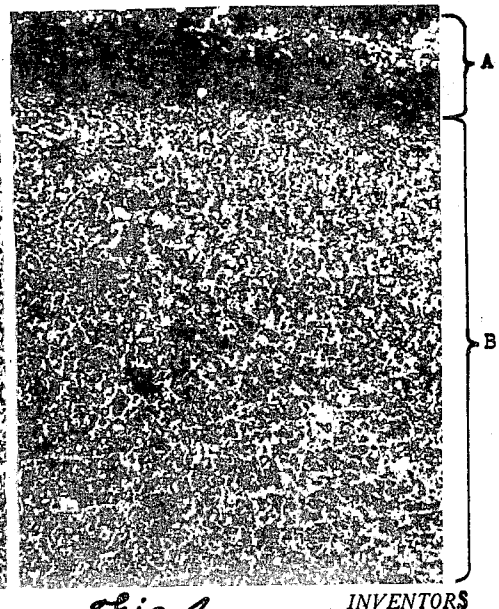


Fig. 4

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2,765,227

TITANIUM CARBIDE COMPOSITE MATERIAL

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4 Claims. (Cl. 75—203)

This invention relates to titanium carbide based articles which are resistant to mechanical and chemical stresses at a high temperature and which are exposed to oxidizing, combustion and fuel contaminated gases and to processes for manufacturing the articles. This is an improvement of the invention disclosed in application, Ser. No. 184,392, filed September 12, 1950, now Patent No. 2,694,007, issued November 9, 1954.

In accordance with the invention, skeleton bodies are produced by mixing titanium carbide with certain metals such as cobalt, nickel, chromium, iron and their alloys adapted to form a binder on the particles of the original titanium carbide. The skeleton bodies may be infiltrated with nickel, cobalt, chromium and their alloys. Articles produced in accordance with the present invention will resist exposure for prolonged periods to oxidizing gases, combustion and fuel contaminated gases at a temperature of 900° C. and above.

The titanium carbide powder employed contains in accordance with this invention an appreciable amount of free carbon uniformly dispersed in the form of a physical coating on the surface of the titanium carbide particles. The powder also contains a high combined carbon content approaching the stochiometric value within 10%. The rupture strength, ductility and other physical properties of the final product will be considerably superior to bodies of the same composition and produced in identical manner, but from a titanium carbide powder with a low free carbon content and a combined carbon content of less than 90% of the stochiometric value.

Titanium carbide containing free carbon will lead also to greater ease of manufacture and elimination of detrimental size changes, imperfections and disfigurations of the composite bodies during manufacture, and especially during the infiltration operation. This phenomenon is due to a particular mechanism of sintering, alloying and strengthening of the bonds between the individual titanium particles that constitute the porous skeleton prior to infiltration. Diffusion and alloying of the free carbon with nickel or cobalt films smeared over the titanium carbide particles in a preceding ball milling operation, and designed to form a binder or cement holding the titanium particles together in a coherent skeleton mass, will result in a markedly increased rigidity of the cemented titanium carbide skeleton structure at the temperature and at the instance of infiltration of the skeleton with the molten nickel-base or cobalt-base corrosion resistant alloy. It is due to this increased rigidity of the interposed carbon containing binder or cementing alloy phase that the skeleton body retains its shape, contours, structural continuity, uniformity in particle concentration and coherence in the face of the vigorous and disruptive forces and stresses inherent in the infiltration of the liquid alloy through the pore system, these forces and stresses being caused by capillary forces, diffusion and dissolution of solid titanium carbide particles or grains, or of liquid binder metal films, concentration gradients, and local dislocation of skeleton fragments. Where no, or insufficient quantity of free carbon, is available for alloying and thereby strengthening of the binder metal films of the titanium carbide skeleton, as for example when a low free carbon containing type of titanium carbide powder is used, the just mentioned forces and stress concentrations, due to local composition changes, are unopposed or made even more effective by the presence of free metallic titanium in such power, due to the strong alloying capacity of the free metallic titanium with the binder metals cobalt and nickel and the infiltrant alloys having these metals as major constituents.

The heat treating and refining operation of a titanium carbide powder, containing a substantial proportion of free carbon, tends to result in products of a higher rupture strength and ductility, especially at elevated temperatures in the order of 1000° C. Such refining treatment, consisting of heating the titanium carbide powder to a temperature between 2000 and 2300° C. in pure hydrogen, prior to admixing and smearing-on of the binder metal in the ball mill, has been found to cause a partial diffusion and reaction of the free carbon with the impurities and metallic ingredients contained in the titanium carbide powder. Traces of TiO_2 react with the carbon to the volatile carbon oxides and metallic titanium which, in turn, is carburized to titanium carbide.

The investigation represents an important further development of the invention described in patent application Ser. No. 184,392 while the mechanism of strengthening the interposed binder or cementing phase of the titanium carbide skeleton bodies during their infiltration is fully maintained.

It is, therefore, an important object of the invention to considerably improve the stability and resistance of the titanium carbide based articles to high-temperature mechanical and chemical stresses and particularly also to atmospheric and gaseous attack and corrosion at a high temperature of 900° C. and above.

It is another object of the invention to preserve this resistance to chemical influences practically unimpaired and for timely unlimited periods of exposure.

It is an important object of the invention to form within the skeleton bodies to be infiltrated a strong, rigid, tenacious cement network, which will assure the shape stability and coherence of the skeleton bodies during their infiltration.

It is a further object of the invention to produce a titanium carbide based material for use in the production of skeleton bodies which is extremely stable and will retain its original composition.

This is attained by mixing chromium powder to a free carbon containing titanium carbide powder. This mixture will be the initial material for the production of the skeleton bodies. By maintaining certain heat-operative conditions the major part of the added chromium powder will be converted into a solid chromium carbide-titanium carbide solution.

The admixture of chromium components to carbon containing titanium carbide for the production of refractory titanium carbide compositions has often been sug-

gested and mixtures of titanium carbide with varying quantities of coke and Cr_2C_3 are known.

Alloys which contain titanium carbide and chromium, and a part of the latter as a solid chromium carbide-titanium carbide solution, have been recommended for the manufacture of high temperature resistance bodies. Moreover, it is known that the liquid phase formed during sintering may consist of an alloy of nickel or cobalt with carbon, titanium and that part of the chromium which is not in solid condition in the titanium carbide.

As distinguished from prior practices the present invention requires free carbon in the initial titanium carbide mixture which is so controlled as to enable the formation of the solid chromium carbide-titanium carbide solution from practically all of the added chromium and to provide a sufficient amount of free carbon for the metallic binder which according to the invention is added to the titanium carbide containing the solid chromium carbide-titanium carbide soluton.

However, according to the present invention a sufficient quantity of chromium metal powder is mixed with a 1.2 to 3.0 per cent free carbon containing titanium carbide powder as to produce a solid chromium carbide-titanium carbide solution, preferably at a ratio of about 10% by weight of chromium carbide in the solid solution.

The heat treatment in application Ser. No. 184,392 is a refining treatment for the elimination of undesirable impurities. As distinguished from that, the present is an alloying treatment which has profound effects on the entire process and on the properties of the resulting end product. If enough chromium powder is added to the high free carbon containing titanium carbide powder, it will combine with the free carbon into the chromium carbon compound Cr_3C_2. If the heat treatment is carried out long enough and at a sufficiently high temperature, the chromium carbide will be dissolved by the titanium carbide, which should be preferably in an amount up to approximately 10% by weight. It has been found that probably on account of a reduced affinity to oxygen, the titanium carbide-chromium carbide solid solution offers a surprisingly great high-temperature stability and resistance to gas and particularly oxygen attack as measured by weight gained through absorption of oxygen at such temperatures by a body of this solid solution compound. For example, when exposing such a body to air at 1000° C., the weight gain was found to be only between ½ and 1/10 of that of similarly exposed bodies made of titanium carbide only. There is ample evidence that the chromium carbide dissolved in the titanium carbide tends to lower the rate of decarburization, thermal decomposition, and oxidation of both the metal and carbon.

It is for this reason that the presence of the titanium carbide-chromium carbide solid solution in the skeleton material in substantial amounts is most advantageous. It is desirable for reasons of optimum resistance to high temperature oxidation to reach as closely as possible to the saturation limit of about 10% of the Cr_3C_2 in solid solution with the titanium carbide. An excess amount of Cr_3C_2 as separate phase would have the added advantage of being available in the subsequent skeleton sintering process for the purpose of alloying with the binder metal films imparting to the latter increased strength and rigidity.

Furthermore, it has been found advantageous to retain a minor proportion of free chromium in the original material mixture which is available for alloying with the binder metal in the subsequent skeleton sintering operation and contributing to strengthening of the bonds between the particles in the skeleton during infiltration.

For optimum heat resistance and lowest possible specific gravity of the end product the amount of chromium powder that is added to the titanium carbide powder is limited to between 5 and 15%, and preferably 5 and 10%. The addition of less than 5% results in the formation of an inadequate proportion of the heat resistant titanium carbide-chromium carbide solid solution in the skeleton with consequent rapid thermal decomposition and corrosion of the end product when exposed to oxidizing or corrosive atmosphere conditions at a high temperature.

The use of a predetermined heating cycle for the production of the titanium carbide-chromium carbide solid solution powder is advisable to insure a product which contains the solid solution carbide phase as well as a certain proportion of the single carbides of titanium and/or chromium and also a certain proportion of about up to 3% free metallic chromium and up to 0.3% free carbon.

The temperature which is required to obtain such a multi-component powder lies between 2150 and 2315° C., the preferable operating temperature being within this range inversely proportional to the percentage of chromium added. The time which is required for the completion of the treatment at the required temperature lies between 20 and 60 minutes, the exact time within this range being directly dependent on the weight of the charge within the range of 300 and 1000 grams.

Powder mixtures thus treated and originally containing 5, 10 and 15% metallic chromium powder, respectively, contained as a consequence of the above-mentioned heat-treatment the following constituents:

Upon admixture of	5% Cr	10% Cr	15% Cr
Total carbon (in percent)	18.77	17.98	16.71
Free Carbon (in percent)	0.62	0.35	0.28
Combined carbon (in percent)	18.15	17.63	16.43
Total chromium (in percent)	3.64	7.45	14.17
Free chromium (in percent)	0.20	0.81	2.76
Combined chromium (in percent)	3.44	6.64	11.41

Taking into consideration that in all cases the combined chromium is present in the form of the carbide Cr_3C_2, the values of 3.97%, 7.66% and 13.18% Cr_3C_2 were found for the products from the original mixtures containing 5, 10 and 15% chromium. The corresponding values for titanium carbide were found to be 88.10, 81.80 and 73.20%. Thus, only in the products from the mixture containing an initial chromium amount of 15% did the Cr_3C_2 content exceed the upper limit of the solid solution of 10%, the product consisting of 81.4% of the 10% titanium carbide-chromium solid solution and 4.88% of Cr_3C_2. The product from the mixture having an initial chromium content of 5% contained 39.7% solid solution carbide and 52.37% titanium carbide, and the product from the mixture having an initial chromium content of 10% contained 76.6% of the solid solution carbide and 12.86% titanium carbide. The presence of the different carbide phases in each of the powders was confirmed by microscopic and X-ray examination.

The complex carbide powder obtained by the aforementioned alloying heat treatment is now processed into heat and corrosion resistant articles in a manner similar to that outlined in copending application Ser. No. 184,392.

The powder mass is crushed and pulverized to pass a 200 mesh sieve, and is then ball-milled, dry or wet, with from about 5–10% by weight of nickel, iron or cobalt powder of 325 mesh size. In the case of wet milling water, carbon tetrachloride, alcohol and benzine have all been found to be suitable. A period of 24 hours suffices to form smeared-on surface films of the binder metal, nickel, iron or cobalt, on the hard alloy particles. Microscopic examination established that chromium, in the form of free particles or as occluded sections within the carbide particles, was covered by these softer binder metals, nickel, iron or cobalt.

The resulting powder is thereupon compacted into skeleton bodies of the desired shape in conformity with the final articles to be produced, for instance by the methods disclosed in copending patent applications Ser. Nos. 787,514 and 795,101, each now abandoned; the former referring to cold pressing, preferably in conjunction with

rampacking and dynamic loading, and the latter referring to hot pressing, the pressing temperatures preferably corresponding to those of noticeable solubility between the carbide and the binder metal or alloy phases.

Care must be taken in the performance of the hot-pressing processes that the interconnected pore system of the skeleton bodies is fully maintained in the process of compaction to assure full and complete infiltration at a later stage.

Following their formation, the skeleton bodies are subjected to a sintering treatment. The procedure employed may be the one of copending patent application Ser. No. 184,392 filed September 12, 1950, which also serves the purpose of diffusion alloying the free carbon with the binder metal and thereby strengthening the bonds between the individual particles of the skeletons. The result can be further improved by a diffusion of the free carbon into the free or occluded chromium particles of the skeleton material, whereby additional chromium carbide (Cr_3C_2), is formed. As a result, skeleton bodies of great rigidity up to and including the temperature of the subsequent infiltration step are obtained.

The penetration of the pore system without destruction of the structural continuity or coherence of the skeleton body was confirmed by the surprising strength and rigidity of the skeleton bodies at the temperature and instance of infiltration. Even in the case of articles with a larger cross-section of up to several square inches, which required prolonged times of infiltration of up to two hours at 1525 to 1625° C., no cleaving, deformation or distortion of the skeleton body or the resulting composite body could be observed.

The physical properties that were obtained with infiltrated complex chromium-bearing titanium carbide bodies, in conformity with the invention, are apparent from Tables I and II. It is also evident that the addition of chromium in percentages of up to 15% does not reduce the values obtained in comparison with a similar material that contains no chromium.

The beneficial effect of the chromium mixture becomes still more apparent from a comparison of the strength and ductility (deflection) values of test specimens found immediately after processing and test specimens that have been subjected to the influence of oxygen upon exposure to air at 1000° C. for prolonged periods of time up to 100 hours, as recited in the following tables:

TABLE I

Physical properties of Nichrome-infiltrated titanium carbide composites from high free carbon-containing titanium carbide powder mixtures having different amount of chromium additions

DIRECTLY AFTER PROCESSING

Percent Chromium	Transverse Rupture at Room Temp., p. s. i.	Transverse Rupture at 1,000° C., p. s. i.	Deflection under Break Load at 1,000° C., inches
0	216,000	97,100	0.128
	162,200	99,800	0.238
5	200,500	87,200	0.221
	207,500	86,000	0.217
10	192,000	82,200	0.1597
	166,500	96,800	0.267
15	162,500	77,500	0.1402
	166,500	90,300	0.1195
AFTER EXPOSURE TO AIR AT 1,000° C. FOR 100 HOURS			
0	131,800	70,400	0.015
	121,800	73,000	0.0412
5	167,500	92,300	0.1645
	195,700	99,300	0.288
10	197,500	94,500	0.195
	160,900	81,500	0.235
15	138,800	93,800	0.0925
	144,000	77,800	0.1895

TABLE II

Physical properties of vitallium-infiltrated titanium carbide composites from high free carbon-containing titanium carbide power mixtures having different amounts of chromium additions

DIRECTLY AFTER PROCESSING

Percent Chromium	Transverse Rupture at Room Temp., p. s. i.	Transverse Rupture at 1,000° C., p. s. i.	Deflection under Break Load at 1,000° C., inches
0	183,000	137,500	0.102
	151,000	133,000	0.088
5	171,300	126,400	0.047
	157,500	138,200	0.1155
10	130,800	104,200	0.0575
	145,200	114,000	0.029
15	140,000	127,000	0.0745
	126,000	117,000	0.086
AFTER EXPOSURE TO AIR AT 1,000° C. FOR 100 HOURS			
0	138,000	81,700	0.0165
	134,000	90,800	0.031
5	165,700	130,800	0.125
	162,400	124,700	0.028
10	168,200	104,500	0.0295
	171,100	112,000	0.0325
15	178,700	111,200	0.0845
	162,300	121,600	0.0745

It can be noticed that the Nichrome and Vitallium infiltrated materials containing no chromium show a reduction in strength at 1000° C. of approximately 30–35% and even greater reduction in ductility at 1000° C., whereas the corresponding materials that contain chromium retain their strength and ductility after the prolonged exposure to high temperature oxidation.

The beneficial effect of the chromium addition towards stabilizing the carbide structure by forming a complex chromium-bearing solid solution carbide phase is further illustrated by the photomicrographs shown in attached Figs. 1–4.

Fig. 1 shows the microstructure at 100 diameters magnification of a skeleton body of plain titanium carbide that was infiltrated with Nichrome alloy and thereafter subjected to an exposure to still air at 1000° C. for 100 hours. The photomicrograph shows a field near the edge and clearly pictures the oxide layer (A) on top, the Nichrome-infiltrated carbide-base structure (B) on the bottom, and an intermediate layer of decarburized titanium-base alloy (C).

Fig. 2 shows the microstructure at 100 diameters magnification of a skeleton body of the titanium carbide-chromium carbide solid solution type, which was likewise infiltrated with Nichrome alloy and afterwards subjected to the same air exposure test at 1000° C. for 100 hours. The photomicrograph again shows a field near the edge, and clearly pictures the oxide layer (A) on top, the Nichrome-infiltrated carbide-base structure (B) on the bottom. The lack of the intermediary decarburized alloy layer is obvious, and so is the sharp and clear-cut transition between the infiltrated carbide-base structure and the oxide layer.

Fig. 3 shows the microstructure at 200 diameters magnification of a skeleton body of a plain titanium carbide that was infiltrated with Vitallium alloy and thereafter subjected to an exposure to still air at 1000° C. for 100 hours. The photomicrograph again shows a field near the edge and clearly pictures the inner part of the oxide layer (A) on top, the Vitallium-infiltrated carbide-base structure (B) on the bottom, and an intermediate, graduated layer of partially decarburized titanium carbide (C). The progressive increase in the light (titanium-base) alloy phase towards the oxide layer at the edge is a clear indication of the decarburizing reaction that takes place parallel with the oxidation of the surface area.

Fig. 4 shows the microstructure at 200 diameters magnification of a skeleton body of the titanium carbide-chromium carbide solid solution type which was likewise infiltrated with the Vitallium alloy and afterwards subjected to the same air exposure test at 1000° C. for 100 hours. The photomicrograph again shows a field near the edge and clearly pictures the oxide layer (A) on top, the Vitallium-infiltrated carbide-base structure (B) on the bottom. Again, as in Fig. 2, the lack of an intermediate layer of partially or fully decarburized infiltrated base metal is apparent. The uniform distribution of the carbide phase in the infiltrant alloy matrix up to the border with the oxide layer is also apparent.

These photomicrographs clearly show that in the material that lacks chromium a deep layer of partially (Fig. 3) or completely (Fig. 1) decarburized (titanium-base) alloy was formed between the surface oxide layers and the infiltrated composite titanium carbide-base structure. On the other hand, no such decarburized alloy layer was found in the chromium containing material. Moreover, the oxide layer formed during 100 hour exposure to still air at 1000° C. was found to be only approximately ⅓ to ½ as deep as the former (250–300 microns and 200–250 microns average thickness for the plain titanium carbide-infiltrated with Nichrome and Vitallium, respectively, versus 70–110 microns and 60–100 microns average thickness for the infiltrated chromium carbide-titanium carbide solid solution type of material infiltrated with Nichrome and Vitallium, respectively). The formation of the deep decarburized alloy layer and the much heavier oxide layer on the material without chromium, during the exposure to oxygen at 1000° C. for 100 hours and more, accounts for the previously mentioned reduction in physical properties.

The following examples, describing the production of a bar-shaped article, illustrate the invention more in detail:

EXAMPLE I

A high free carbon containing titanium carbide powder of a 325 mesh size and containing 75.96% titanium, 18.00% combined carbon and 2.53% free carbon plus 5% electrolytic chromium powder of a 325 mesh size is charged into a graphite crucible and heat treated in a dry hydrogen atmosphere at a temperature of 2300° C. for a period of about 30 minutes. An agglomeration takes place of the powder; the agglomerated mass is crushed and passed through a 140 mesh screen.

10 weight percent of carbonyl nickel powder of a 400 mesh size is mixed with the titanium carbide plus chrominum powder; the mixture is finely disintegrated in a stainless steel ball mill for 24 hours.

14 grams of the powder mixture are charged in a graphite mold and hot pressed in the same at a temperature of 1650° C. into a bar-shaped skeleton having a density of about 60% by volume, whereupon the article is sintered in a graphite boat in Norblack pack at a temperature of 1500° C. for about one hour, and in dry hydrogen atmosphere to burn away impurities.

The skeleton is now put in an alundum boat located in a graphite carrier and infiltrated with 14.60 grams of Nichrome for a period of 20 minutes at a temperature of 1530° C.

The density of the final bar is 6.57 g./cc. and the total weight 28.60 grams.

Example 2

The procedure, as described in Example 1, is changed by adding 10% electrolytic chromium powder and infiltrating with 14.30 grams of Nichrome.

The density of the final bar is 6.64 g./cc., and the total weight 28.31 grams.

Example 3

The procedure, as described in Example 1, is changed by adding 15% electrolytic chromium powder and infiltrating with 14.05 grams of Nichrome.

The density of the final bar is 6.72 g./cc., and the total weight 28.05 grams.

Example 4

A high free carbon containing titanium carbide powder of a 325 mesh size and containing 75.96% titanium, 18.00% combined carbon and 2.53% free carbon plus 5% electrolytic chromium powder of a 325 mesh size is charged into a graphite crucible and heat treated in a dry hydrogen atmosphere at a temperature of 2300° C. for a period of about 30 minutes. An agglomeration takes place of the powder; the agglomerated mass is crushed and passed through a 140 mesh screen.

10 weight per cent of cobalt powder of a 325 mesh size is mixed with titanium carbide plus chromium powder; the mixture is finely disintegrated in a stainless steel ball mill for 24 hours.

14 grams of the powder mixture are charged in a graphite mold and hot pressed in the same at a temperature of 1650° C. into a bar-shaped skeleton having a density of about 60% by volume, whereupon the article is sintered in a graphite boat in Norblack pack at a temperature of 1500° C. for about one hour, and in a dry hydrogen atmosphere to burn away impurities.

The skeleton is now put in an alundum boat located in a graphite carrier and infiltrated with 14.77 grams of Vitallium for a period of twenty minutes at a temperature of 1530° C.

The density of the final bar is 6.51 g./cc. and the total weight 28.77 grams.

Example 5

The procedure, as described in Example 4, is changed by adding 10% electrolytic chromium powder and infiltrating with 14.02 grams of Vitallium.

The density of the final bar is 6.58 g./cc. and the total weight 28.02 grams.

Example 6

The procedure, as described in Example 4, is changed by adding 15% electrolytic chromium powder and infiltrating with 13.68 grams of Vitallium.

The density of the final bar is 6.60 g./cc. and the total weight 27.68 grams.

It will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific exemplification thereof will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims they shall not be limited to the specific exemplifications of the invention described herein.

What is claimed is:

1. In a method for producing by infiltration heat-resistant titanium-base carbide articles having improved stability and resistance to mechanical stresses and chemical attack, including resistance to atmospheric and gaseous corrosion, at elevated temperatures of 900° C. and above, the improvement which comprises intimately mixing titanium carbide powder containing controlled amounts of free carbon in the range of about 1.2% to 3% with 5% to 15% by weight of chromium powder, heat treating the mixed powders at a temperature ranging from about 2150° C. to 2315° C. in a reducing atmosphere to convert a major portion of the chromium to chromium carbide by reaction with free carbon whereby a multi-component intermediary product is obtained of controlled composition comprising some free carbon, free chromium not exceeding 3% by weight of the mixture and titanium carbide containing chromium carbide in solid solution therewith, finely disintegrating the thus heat treated powder and mixing therewith not over 10% by weight of a binder metal powder selected from the group consisting of nickel, cobalt, iron and their alloys with each other to form a binder metal coating on the surface of said carbide particles, shaping said coated carbide particles into a porous skeleton body having intercommunicating pores therethrough, sintering the skeleton body at an elevated

temperature to form a strongly cemented network by reaction of the binder metal with the free carbon, the free chromium and with the carbides of the skeleton, and then infiltrating the thus-sintered and cemented skeleton body with a heat resistant metal selected from the group consisting of nickel, cobalt, their alloys with each other, and with iron, chromium, tungsten and molybdenum.

2. In a method for producing by infiltration heat-resistant titanium-base carbide articles having improved stability and resistance to mechanical stresses and chemical attack, including resistance to atmospheric and gaseous corrosion at elevated temperatures of 900° C. and above, the improvement which comprises intimately mixing titanium carbide powder containing controlled amounts of free carbon in the range of about 1.2% to 3% with 5% to 15% by weight of chromium powder, heat treating the mixed powders at a temperature ranging from about 2150° C. to 2315° C. for about 20 to 60 minutes in a reducing atmosphere of hydrogen to convert a major portion of the chromium to chromium carbide by reaction with free carbon whereby a multi-component intermediary product is obtained of controlled composition comprising free carbon up to 0.3%, free chromium not exceeding 3% by weight of the mixture and titanium carbide containing chromium carbide in solid solution therewith, finely disintegrating the thus heat treated powder and mixing therewith 5 to 10% by weight of a binder metal powder selected from the group consisting of nickel, cobalt, iron and their alloys with each other to form a binder metal coating on the surface of said carbide particles, shaping said coated carbide particles into a porous skeleton body having intercommunicating pores therethrough, sintering the skeleton body at an elevated temperature above the melting point of the binder metal to form a strongly cemented network by reaction of the binder metal with the free carbon, the free chromium and with the carbides of the skeleton, and then infiltrating the thus sintered and cemented skeleton body with a heat resistant metal selected from the group consisting of nickel, cobalt, their alloys with each other, and with iron, chromium, tungsten and molybdenum.

3. In a method of producing by infiltration heat-resistant titanium-base carbide articles having improved stability and resistance to mechanical stresses and chemical attack, including resistance to atmospheric and gaseous corrosion, at elevated temperatures of 900° C. and above, the improvement which comprises intimately mixing titanium carbide powder containing controlled amounts of free carbon in the range of about 1.2% to 3% with 5% to 10% by weight of chromium powder, heat treating the mixed powders at a temperature ranging from about 2150° C. to 2315° C. for about 20 to 60 minutes in a reducing atmosphere of hydrogen to convert a major portion of the chromium to chromium carbide by reaction with free carbon whereby a multi-component intermediary product is obtained of controlled composition comprising free carbon up to 0.3%, free chromium not exceeding 3% by weight of the mixture and titanium carbide containing chromium carbide in solid solution therewith, finely disintegrating the thus heat treated powder and mixing therewith 5% to 10% by weight of a binder metal powder selected from the group consisting of nickel, cobalt, iron and their alloys with each other to form a binder metal coating on the surface of said carbide particles, hot pressing said coated carbide particles into a porous skeleton body until said particles occupy about 50 to 70% of the body volume, said skeleton having intercommunicating pores therethrough, sintering the skeleton body at an elevated temperature above the melting point of the binder metal to form a strongly cemented network by reaction of the binder metal with the free carbon, the free chromium and with the carbides of the skeleton, and then infiltrating the thus sintered and cemented skeleton body with a heat resistant metal selected from the group consisting of nickel, cobalt, their alloys with each other, and with iron, chromium, tungsten and molybdenum at a temperature above the melting point of the heat resistant metal.

4. In a method for producing heat-resistant infiltrated titanium-base carbide articles in which titanium carbide is mixed with a binder metal selected from the group consisting of nickel, cobalt, iron and their alloys with each other, and shaped into a porous skeleton body which is then sintered to produce a strongly cemented skeleton body which is thereafter infiltrated with a heat resistant infiltrant metal, the improvement which comprises mixing controlled amounts of about 5% to 15% chromium powder with titanium carbide powder having a controlled carbon content of 1.2% to 3%, subjecting the mixed powders to a heat treatment at a temperature of about 2150° C. to 2315° C. in a reducing atmosphere to convert a major portion of the chromium to chromium carbide by reaction with free carbon whereby a multi-component intermediary product is obtained of controlled composition comprising some free carbon, free chromium not exceeding 3% by weight of the mixture and titanium carbide containing chromium carbide in solid solution therewith from which infiltrated titanium-base carbide articles can be produced having improved stability and resistant to mechanical stresses and chemical attack, including resistance to atmospheric and gaseous corrosion, at elevated temperatures of 900° C. and above.

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