July 10, 1956 W. W. WELLBORN 2,753,621

SINTERED CARBIDE COMPOSITIONS AND METHOD OF MAKING THE SAME

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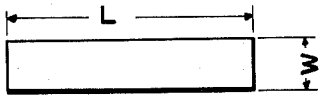

Fig. 1

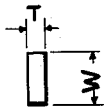

Fig. 3

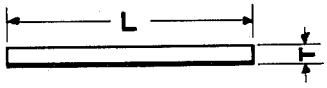

Fig. 2

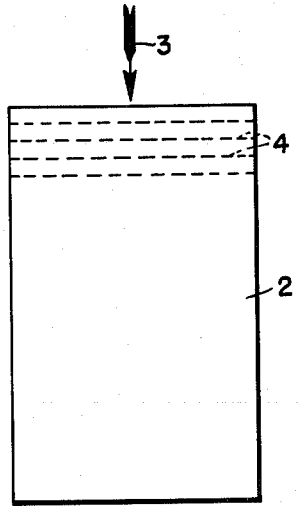

Fig. 4

INVENTOR.
William W. Wellborn

BY
Webb, Mackey & Burden.
HIS ATTORNEYS

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SINTERED CARBIDE COMPOSITIONS AND METHOD OF MAKING THE SAME

William W. Wellborn, Baldwin Borough, Pa., assignor to Firth Sterling, Inc., Pittsburgh, Pa., a corporation of Pennsylvania

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11 Claims. (Cl. 29—182.7)

This invention relates to sintered carbide compositions and to a method of making the same. It relates more particularly to sintered chromium carbide compositions containing two different chromium carbides and one or more binder metals such as nickel or cobalt. The composition preferably contains a small proportion of one or more grain refining elements such as copper or tungsten carbide. The proportions of the various ingredients are such that the coefficient of expansion of the sintered carbide composition in the temperature range of 32° F. to 576° F. is substantially the same as that of steel, i. e., 6.3×10^{-6} inches per inch per ° F.

There are many uses for sintered carbide compositions which have coefficients of expansion substantially equal to that of steel. Such compositions are desirable due to their strength, hardness and wear-resisting qualities, but most of them have coefficients of expansion which differ substantially from that of steel. Sintered carbide compositions according to the present invention, since they have a coefficient of expansion substantially equal to that of steel, find particular application as gauge blocks for measuring steel at different temperatures. They also are desirable for many other uses, for example, as sealing rings for pumps and for bearings where the sintered carbide composition is closely associated with a steel element and it is necessary in order to maintain the desired fit to have the sintered carbide composition and the steel element expand and contract substantially equally.

The accompanying drawings illustrate in a diagrammatic manner a gauge block and a method of making it.

Figure 1 is a plan view of the gauge block,

Figure 2 is a side elevation thereof,

Figure 3 is an end elevation thereof, and

Figure 4 is a side elevation of a billet pressed from powder and given a preliminary sintering treatment, the figure illustrating how the billet is severed into a plurality of gauge blocks.

My sintered carbide composition contains by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, the total of said carbides being between about 86% and 90%, and about 10% to 12% nickel or cobalt, or both, used as binder metals. In the specification and claims, wherever percentages or proportions are given, they mean percentages or proportions by weight, unless otherwise specified. The preferred binder metal is nickel. The composition preferably, although not necessarily, contains a small amount of one or more grain refining elements such as copper or tungsten carbide. Copper is much preferred over tungsten carbide as a grain refining element. Where copper is used, it is employed in an amount from about 0.5% to 2.0% of the composition. Where tungsten carbide is used, it is employed in an

amount between about 0.5% and 3.0% of the composition.

A preferred composition is:

	Per cent
Cr_3C_2	53
Cr_4C	35
Nickel	11
Copper	1

My sintered carbide composition may be made in the following manner.

Mix No. 1 is made by mixing Cr_2O_3 and carbon in such proportions that, when reacted, it forms Cr_3C_2 according to Reaction 1.

REACTION 1

$$3Cr_2O_3+13C=2Cr_3C_2+9CO$$

Mix No. 2 is made by mixing Cr_2O_3 and carbon in such proportions that, when reacted, it forms Cr_4C according to Reaction 2.

REACTION 2

$$2Cr_2O_3+7C=Cr_4C+6CO$$

Mixes 1 and 2 are heated separately in a hydrogen furnace to carry out Reactions 1 and 2, employing, for example, a temperature of 2700° F. for two hours. The Cr_3C_2 and Cr_4C so produced are crushed and mixed together and the mixture is then ball milled for a period of, say, 48 hours in order to intimately mix the carbides and reduce them to fine particles. The nickel or cobalt, or both, are then added and if the composition is to contain copper or tungsten carbide, they are added and the mixture is ball milled for a period of, say, 72 hours. A pressing lubricant, for example, paraffin, in a small amount, say 1½%, is added to the powder mixture. The mixture is then pressed into a billet under a pressure which may be 10 tons per square inch and is then given a preliminary sintering at a temperature of, say, 1300° F. in hydrogen for one hour. The billet which has been given a preliminary sintering is then severed into a plurality of bodies and the bodies are then given a final sintering at a temperature higher than the preliminary sintering in order to produce strong articles, the temperature employed being, say, 2700° F. to 2800° F. for a period of 30 minutes to 90 minutes, the sintering being carried out in a hydrogen furnace. Thereafter, the article, if desired, is diamond lapped or otherwise ground or finished to accurate dimensions.

The following example further illustrates my invention:

Example

18.625 lbs. of Cr_2O_3 and 6.375 lbs. of carbon were mixed to form mix No. 1. 15.6 lbs. of Cr_2O_3 and 4.40 lbs. of carbon were mixed to form mix No. 2. The two mixes were heated separately in a hydrogen furnace at 2700° F. for two hours. Mix No. 1, when reacted according to Reaction No. 1, produced 12.25 lbs. of Cr_3C_2 containing 13.33% of carbon. Mix No. 2, when reacted according to Reaction No. 2, produced 8.96 lbs. of Cr_4C containing 5.45% of carbon.

The Cr_3C_2 and Cr_4C were crushed, mixed together and ball milled for 48 hours. The mixture contained about 57% Cr_3C_2 and 43% Cr_4C. Nickel and copper in amounts to provide 11% nickel and 1% copper were added to the carbides and the mixture was ball milled for 72 hours. Thereafter, 1½% of paraffin dissolved in a solvent was added to the mixture. The mixture was

then further processed to form gauge blocks such as illustrated in Figures 1–3.

Each of the gauge blocks has a length L, a width W and a thickness T. The powder was pressed into a billet 2 as shown in Figure 4, this billet having a length many times greater than the thickness T of the gauge blocks to be formed therefrom. In carrying out the pressing operation, pressure was exerted in the direction of the longitudinal axis of the billet as indicated by the arrow 3. The pressure mounted to 10 tons per square inch. The compressed billet 2 was then subjected to a preliminary sintering in a hydrogen furnace at a temperature of 1300° F. for one hour so as to produce a coherent mass which could be handled and shaped but which was not so hard as to make shaping difficult. The billet was then sawed transversely into a plurality of gauge blocks by sawing along the lines 4. Thereafter, the gauge blocks were subjected to a final sintering in a hydrogen furnace at a temperature of 2700° F.–2800° F. for one hour.

Gauge blocks, or other articles made in the manner described, may then be diamond lapped or otherwise ground and finished to accurate dimensions.

The article produced according to the example had a coefficient of expansion in the temperature range of 32° F. to 576° F. of 6.3×10^{-6} inches per inch per ° F., a Rockwell A hardness of 90 and a transverse breaking strength of 100,000 pounds per square inch. The Cr_3C_2 in the sintered composition was in the form of columnar grains, whereas the Cr_4C was in the form of substantially equi-axed grains.

By pressing the powder into a billet having a length many times the thickness of the desired article and then severing the billet transversely to form a plurality of the articles as illustrated in Figure 4, articles having substantially the same coefficient of expansion in all directions are obtained. In other words, the coefficient of expansion in the direction of the length L, in the direction of the width W, and in the direction of the thickness T are substantially identical when the method illustrated in Figure 4 is employed.

The invention is not limited to the preferred embodiment but may be otherwise embodied or practiced within the scope of the following claims.

I claim:

1. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90%, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, and about 10% to 12% of at least one binder metal of the group consisting of nickel and cobalt.

2. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90%, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, about 10% to 12% of at least one binder metal of the group consisting of nickel and cobalt, and about 0.5% to 3.0% of at least one grain refining agent of the group consisting of copper and tungsten carbide.

3. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90%, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, about 10% to 12% of at least one binder metal of the group consisting of nickel and cobalt, and about 0.5% to 2.0% copper.

4. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90%, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, about 10% to 12% of at least one binder metal of the group consisting of nickel and cobalt, and about 0.5% to 3.0% tungsten carbide.

5. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90%, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, and about 10% to 12% nickel.

6. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90%, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, about 10% to 12% nickel, and 0.5% to 2.0% copper.

7. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 53% Cr_3C_2, about 35% Cr_4C, and about 10% to 12% of at least one binder metal of the group consisting of nickel and cobalt.

8. A sintered carbide composition having a coefficient of expansion substantially equal to that of steel, said composition containing by weight about 53% Cr_3C_2, about 35% Cr_4C, about 10% to 12% of at least one binder metal of the group consisting of nickel and cobalt, and about 0.5% to 2.0% copper.

9. A method of making a sintered carbide composition article having a coefficient of expansion in all directions substantially equal to that of steel, which comprises providing a powder mixture containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90%, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, and about 10% to 12% of at least one binder metal of the group consisting of nickel and cobalt, pressing said mixture into a billet having a length many times the thickness of the article to be produced therefrom, the pressure being exerted in the direction of the longitudinal axis of the billet, subjecting the billet to a preliminary sintering to form a coherent mass which can be handled and shaped, severing the billet transversely into a plurality of articles, and subjecting said articles to further sintering at a temperature higher than that employed in the preliminary sintering in order to form a strong article.

10. A method of making a sintered carbide composition having a coefficient of expansion substantially equal to that of steel, which comprises separately forming Cr_3C_2, separately forming Cr_4C, mixing the Cr_3C_2, the Cr_4C and at least one binder metal of the group consisting of nickel and cobalt to form a batch containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about 86% and 90% of the batch, the proportion of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, and about 10% to 12% of at least one of said binder metals, and pressing and sintering said batch.

11. A method of making a sintered carbide composition having a coefficient of expansion substantially equal to that of steel, which comprises separately forming Cr_3C_2 by heating to reaction temperature a mixture of chromium oxide and carbon in substantially stoichiometric proportions to form Cr_3C_2, separately forming Cr_4C by heating to reaction temperature a mixture of chromium oxide and carbon in substantially stoichiometric proportions to form Cr_4C, mixing the Cr_3C_2, the Cr_4C and at least one binder metal of the group consisting of nickel and cobalt to form a batch containing by weight about 40% to 60% Cr_3C_2, about 25% to 45% Cr_4C, the total of said carbides being between about

86% and 90% of the batch, the proportions of Cr_3C_2 to Cr_4C being between 1:1 and 7:3, and about 10% to 12% of at least one of said binder metals, and pressing and sintering said batch.

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