July 11, 1933. G. F. TAYLOR 1,918,064

METHOD OF MAKING STRONG, THIN, CEMENTED, CARBIDE DISKS

Filed Sept. 8, 1930

Fig. 1.

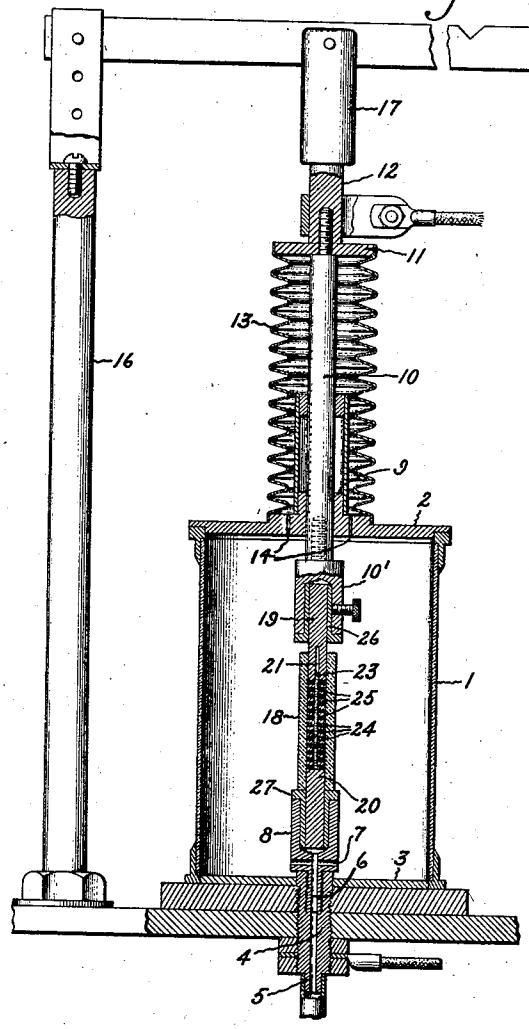


Fig. 2.

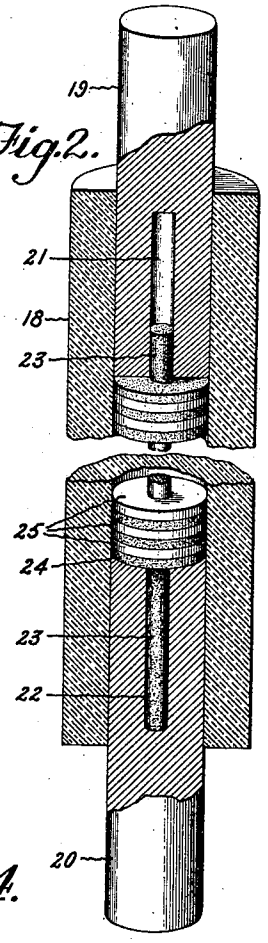


Fig. 3.

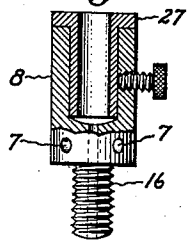
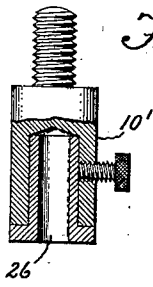


Fig. 4.



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UNITED STATES PATENT OFFICE

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METHOD OF MAKING STRONG, THIN, CEMENTED CARBIDE DISKS

Application filed September 8, 1930. Serial No. 480,330.

The present invention relates to the manufacture of strong, thin, fine-grained, cemented carbide disks, and particularly to disks of this character which have a central opening therethrough and are suitable for use as glass cutters and the like. Cemented carbide compositions are well known and are disclosed in Schröter Patents #1,549,615 and #1,721,416. Such compositions generally consist of a sintered mixture of a carbide for example tungsten carbide, with a cementing or binder medium which has a lower melting point than the carbide, for example cobalt, the cobalt usually comprising from about 3 to about 20% of the composition with the remainder tungsten carbide. While tungsten carbide and cobalt provide the preferred composition other carbides such as molybdenum carbide and other binder elements such as nickel, iron, manganese and uranium may be employed if desired.

Heretofore cemented carbides have been employed extensively as bits for cutting tools. Such bits are relatively thick and mounted on suitable supporting shanks. While attempts have been made to manufacture thin cutting disks of the order of $\frac{1}{16}$ inch in thickness or less from this material, it has been impossible prior to the present invention, to produce a satisfactory, tough, fine-grained disk which would be flat and capable of taking a smooth, sharp, cutting edge when unsupported in a lateral direction.

Cemented carbide is ordinarily somewhat brittle but when formed into very thin sections, it is so brittle that it is practically impossible to grind such a disk to a fine, smooth cutting edge. In addition to brittleness, it is difficult to produce very thin plates of cemented carbide that will lie perfectly flat. Very thin plates of this material whether produced by squirting or by the process outlined in the above Schröter patents are somewhat porous and coarse-grained and have a tendency to become warped when fired at the sintering temperature. If thin plates are made by the hot-press methods disclosed in the copending application of Samuel L. Hoyt, Serial No. 181,536, filed April 6, 1927 and in Gilson Patent No. 1,756,857, such plates are brittle and also coarse grained.

In the prior processes for making cemented carbide, the powdered materials from which the cemented carbide is made is usually in direct contact for an appreciable period of time either with a carbon boat or mold during the sintering operation. It is my present opinion that this contact with carbon for an appreciable time at a high temperature is the main cause of the brittleness and coarse-grained structure found in very thin plates formed by prior processes. Graphite has a tendency to absorb cobalt at the sintering temperature of cemented tungsten carbide and this action tends to increase the brittleness of the cemented material. Coarseness of the grain structure also has the same effect and this latter condition is a function of the time during which the cementing material is heated at the sintering temperature.

In my copending application Serial No. 363,079, filed May 13, 1927, I have disclosed a method for producing thin plates of cemented carbide which are supported laterally by substantially coextensive molybdenum plates. When the sintered plates are supported as disclosed in the above application, it is possible to produce a sharp cutting edge on the disk. The method disclosed in my prior application however is not suitable for the production of laterally unsupported thin plates of cemented carbide of the type described in the present application.

In my prior application, Serial No. 462,368, filed June 19, 1930, I have disclosed an apparatus whereby a hard, tough and unusually fine-grained cemented carbide may be produced by simultaneously applying heat and pressure in a vacuum to powdered materials comprising a hard metal composition. I employ the apparatus disclosed in the latter application in carrying out the present invention.

It is an object of the present invention to provide an improved method for producing thin, cemented carbide disks which are capable of operation without lateral support.

In my copending application Serial #593,-543, filed February 17, 1932, which is a division of the present application, I have claimed a hard, tough, cemented carbide disk produced by the method disclosed in the present application.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. The invention itself however will best be understood from reference to the following specification when considered in connection with the accompanying drawing in which Fig. 1 represents a view partly in section and partly in elevation of an apparatus whereby my invention may be carried into effect. Fig. 2 is a view partly in section and partly in elevation on an enlarged scale of a portion of the apparatus disclosed in Fig. 1, while Figs. 3 and 4 are detail views of portions of the apparatus disclosed in Fig. 1.

Referring to the drawing, I have indicated at 1 a receptacle having a removable cover or closure member 2 and a base portion 3. Extending through the latter is a screw-threaded plug 4 provided with an opening 5 extending therethrough, the latter opening connecting with passageways 6 and 7 in an extension 8 mounted on the upper end of the plug 4. The closure member 2 is provided with a central upwardly extending guide portion 9 adapted to accommodate a movable rod 10. The rod 10 is provided at its lower end with an extension 10′ and carries at its upper end a flat metal plate 11 provided with an extension 12. Plate 11 is of smaller diameter than closure member 2 and is connected to the latter by means of a corrugated flexible member 13, commonly known as a sylphon bellows. The portion of the member 2 which separates the interior of the sylphon from the interior of receptacle 1 is perforated with holes 14 whereby the pressure within the sylphon bellows 13 and the receptacle 1 may be equalized.

Pressure may be applied to the plate 11 through a lever 15 pivoted to a standard 16 and provided with a depending portion 17 which is pivoted to lever 15 and adapted to engage the extension 12 on plate 11. A weight (not shown) may be positioned at any desired point along the lever 15 in order to apply a suitable pressure to the plate 11. If desired, however, the standard 16 and lever 15 may be omitted and pressure applied to plate 11 by the atmosphere only, as hereinafter disclosed.

In fabricating small cemented carbide metal cutting disks, for example disks about 0.15 inch in diameter, a hard glass tube 18 is employed as the mold, the latter having an interior diameter substantially equal to the diameter of the disks to be fabricated, a wall thickness of about ⅛ inch or greater, and a length of about 4 inches or less. Plungers 19 and 20, made of iron or steel or other suitable metal, are mounted in opposite ends of the mold 18. The plungers are each about 2 inches long and provided with central holes 21 and 22 respectively. These holes extend in a lengthwise or axial direction about one-half way through the plungers and accommodate a removable or temporary plug 23, about 30 mils in diameter, which is preferably made of quartz but may be made of graphite.

In carrying out my invention, the tubular glass mold 18 is loaded by placing it in a vertical position, inserting the lower plunger 20 therein to the extent of about ½ inch, then fixing the graphite rod 23 in the hole 22 of the plunger. A thin, graphite disk 24 having a central opening therein of the same diameter as the graphite rod 23 is slid over the rod 23 so as to rest on the upper end of the plunger 20. Pulverized cemented tungsten carbide 25, for example a powdered mixture consisting of about 13% cobalt and about 87% tungsten carbide in sufficient quantity to produce a sintered disk of about 1/64 inch thick and about 0.15 inch diameter, is weighed out and placed on the graphite disk 24. The powdered material is levelled by means of a relatively long rod (not shown) which may be provided with a central opening therethrough. This rod is inserted in the upper end of the glass mold 18 over the graphite rod 23 and rotated until the powdered material 25 is leveled. The levelling rod is then removed and successive alternate layers of graphite 24 and powdered material 25 inserted and levelled in the mold 18 until the latter is filled to the desired extent. Plunger 19 is then inserted in the upper end of the mold and the latter positioned in receptacle 1 between extensions 8 and 10′ as indicated in Fig. 1. The extensions 10′ and 8 are provided with adjustable bearing sleeves 26 and 27 respectively which accommodate the outer ends of the plungers 19 and 20 and center mold 18 in receptacle and hold the plungers rigidly in such positions that their axes always fall along the same line. Bearing sleeves 26 and 27 may be constructed with openings of various diameters extending therethrough and may be employed to accommodate any desired diameter of plunger.

When the mold 18 has been placed in position, the receptacle 1 is flushed out with hydrogen which may be supplied through the opening 5 in the plug 4. After the hydrogen supply is cut off the receptacle is evacuated by means of a pump (not shown) connected to plug 4. When a desired degree of vacuum has been attained an electric circuit is closed, as in my prior application Serial No. 462,368, through a suitable source

of current supply (not shown) connected to the plug 4 and to the extension 12. This current is of sufficient intensity to heat the several layers of powdered materials 25 to to their sintering temperature. The powdered materials are heated almost instantly to the desired temperature and as they become heated plunger 19 descends and the powdered materials are compressed into a hard, tough, metallic composition which is uniformly fine-grained and capable of taking a very fine smooth cutting edge.

If a glass tube is employed as the mold, the process may be observed clearly. When the electric circuit is closed, the graphite disks within the mold are heated to a visible redness increasing to incandescence. In the meantime the sections of mixed tungsten carbide and cobalt powders are heated to their sintering temperature partly by radiation from the carbon disks and partly by the electric current which flows through the powdered material. At the instant when the various separate portions of powdered material arrive at their sintering temperature, each portion is simultaneously compressed to about one-half its original thickness. This compression of all the disks is completed in merely a fraction of a second. The electric heating circuit is then opened and hydrogen gas readmitted to the receptacle 1. The mold 18 and plungers 19 and 20 are removed from receptacle 1 and while still hot plunged into water thereby breaking the mold and permitting removal of the pressed disks.

Ordinarily, atmospheric pressure alone is sufficient to compress the powdered material to the desired thickness. This pressure however may be supplemented by pressure applied to the lever 15. As in my copending application Serial No. 462,368, the heating current may, if desired, be supplied to the pressed material for a predetermined length of time after the powdered materials have been pressed to the desired thickness, the circuit being controlled, as in the prior application, by a switch 28 mounted on the outer end of lever 15.

Since mold 18 is electrically non-conducting, it is practically a cold mold and therefore a very high pressure may be applied to the sintered material. Moreover, since the powdered materials are heated for an unusually short period of time, for example for about 1/300th or 1/500th of the time required to hot press similar powdered materials according to the process disclosed in the above Hoyt application or Gilson patent, there is practically no opportunity either for grain growth in the pressed material or for absorption of cobalt by the carbon disks. As a result, a very hard, tough and uniformly fine-grained product is obtained which may be supplied with a smooth keen cutting edge.

Cutting disks produced according to my process have a hardness of about 90 to 92 on the Rockwell A scale. While these disks may be supplied with a keen smooth cutting edge, this cannot ordinarily be done with the usual grinding apparatus but may be accomplished by a grinding wheel made of a mixture of cemented tungsten carbide and diamond powder as disclosed in my copending application Serial No. 357,536, filed April 23, 1929.

The small graphite disks may be prepared by cutting off sections of suitable thickness from a graphite rod of the same diameter. The graphite disks keep the sintered disks separate from one another and also prevent plungers 19 and 20 from sticking to the pressed material.

Instead of weighing the separate portions 25 of mixed powdered materials so as to obtain an exact quantity of material in each disk, I may squirt a tube made from a suitable mixture of tungsten carbide, cobalt and starch paste, remove the paste by firing in hydrogen and then cut equal lengths of the tube and separate them, if desired, with paper. The latter may be reduced to carbon by charring, the heat for the latter purpose being furnished by the central graphite rod 23 when heated by the electric current supplied through plug 4 and extension 12.

Although I have illustrated my invention in connection with cemented tungsten carbide, it is not limited to that material alone. For example, I may hot press in a similar manner a mixture of diamond dust and cemented tungsten carbide such as disclosed in the copending application Serial No. 357,536 and form for example disk saws as thin as $\frac{1}{16}$ inch and ½ inch diameter. While such material is not as strong as cemented tungsten carbide alone, its strength may be materially increased by the addition of small molybdenum wires thereto. These wires should be about 0.010 inch in diameter and preferably in the shape of a C or O about $\frac{1}{32}$ inch in diameter. The addition of about 2% by weight of these wires to cemented tungsten carbide and diamond dust should give it sufficient strength to withstand the strain produced in sawing hard materials such as sapphire while the narrow swath and speed of cutting of such a wheel should give it an efficiency far exceeding that of any small abrasive saw now in use. Small molybdenum wires may also if desired be added to the cemented tungsten carbide powdered materials in the proportions indicated above. The molybdenum wires in either case act to reinforce the pressed powdered material in much the same way that steel reinforces concrete.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. The method of producing thin metallic

disks from powdered material which comprises placing alternate layers of said powdered material and carbon in an electrically non-conducting mold, completing an electric circuit through said layers to thereby heat said powdered material to its sintering temperature, maintaining said circuit for a few moments and simultaneously applying pressure to said powdered material.

2. The method of making a fine-grained cemented tungsten carbide cutting disk which comprises placing a layer of a pulverized mixture of tungsten carbide and cobalt between two layers of carbonaceous material in an electrically non-conducting mold, placing said mold in a receptacle, evacuating the receptacle, completing an electric circuit through the pulverized material to thereby heat it to its sintering temperature and simultaneously applying pressure thereto, said circuit being maintained not more than a few seconds.

3. The method of simultaneously making a plurality of thin, cemented carbide disks which comprises placing alternate layers of carbon disks and powdered material comprising said carbide in an electrically non-conducting mold, placing said mold in a receptacle, evacuating said receptacle, completing an electric circuit through said layers to thereby heat the powdered material to its sintering temperature, maintaining said circuit for a few moments, and simultaneously applying pressure to the material in said mold.

4. The method for making a plurality of thin, cemented carbide disks which comprises placing a layer of powdered material comprising said carbide in an electrically non-conducting mold, levelling said powdered material, superimposing a layer of carbonaceous material on said powdered material, filling said mold to a desired extent with alternate layers of said powdered material and carbonaceous material, positioning said mold in a receptacle, evacuating said receptacle, passing an electric current through said powdered and carbonaceous materials to thereby heat the powdered material to its sintering temperature, and simultaneously applying pressure to the material in said mold.

5. In combination, a mold, a pair of oppositely disposed plungers mounted in the mold, means for positioning said mold and plungers in a receptacle, said means comprising a member with an opening therein to accommodate one of said plungers and an oppositely disposed movable member adapted to accommodate the other of said plungers, said members each comprising an adjustable bearing sleeve engaging one of said plungers.

In witness whereof, I have hereunto set my hand this 6th day of September, 1930.

GEORGE F. TAYLOR.