March 8, 1955 P. G. COTTER 2,703,750

METHOD FOR MAKING TITANIUM BONDED DIAMOND TOOLS

Filed Sept. 24, 1952

Fig. 1.

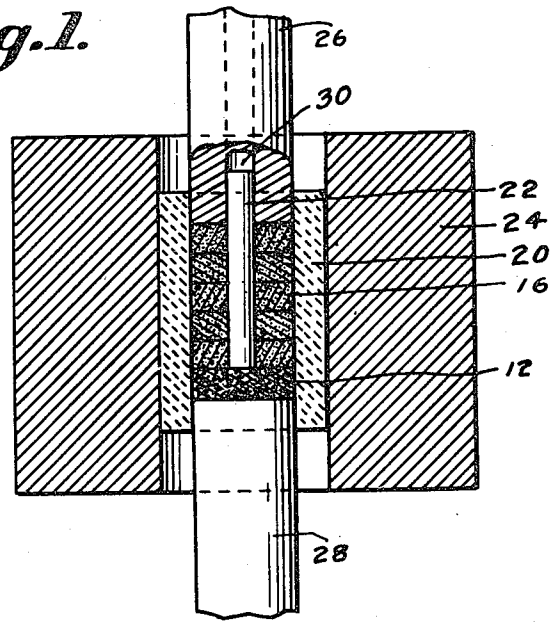




Fig. 2.

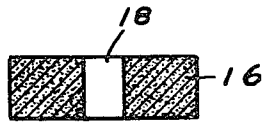


Fig. 3.

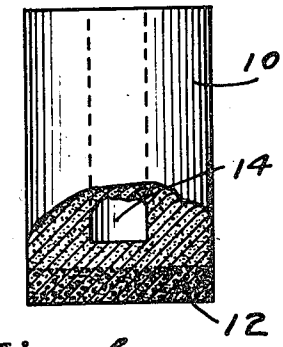


Fig. 4.

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2,703,750

Patented Mar. 8, 1955

2,703,750

METHOD FOR MAKING TITANIUM BONDED DIAMOND TOOLS

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Application September 24, 1952, Serial No. 311,337

4 Claims. (Cl. 51—309)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States for governmental purposes without the payment to me of any royalty thereon in accordance with the provisions of the act of April 30, 1928 (Ch. 460, 45 Stat. L. 467).

This invention relates to cutting and abrading tools, and more particularly to a tool of this type in which a diamond abrasive is held in a matrix of titanium metal and to a method for producing such a tool.

It has been the practice for some time to make diamond cutting tools by placing and retaining diamonds in a sintered matrix of powdered metal or powdered metal alloy. However, it has been difficult to find a metal or metal alloy combining satisfactory tensile strength and corrosion resistance in which the diamond particles may be suitably bonded. Metallic bonded tools of the softer metals and alloys, such as copper and its alloys have had the undesirable quality of often contaminating the abraded article by particles of the metal used for the bonding material. Other harder metals such as iron or iron and tungsten mixture, have presented corrosion difficulties or have been incapable of forming a satisfactory bond with the diamond abrasive when produced by known methods.

As disclosed in my copending application, Serial No. 222,130, the metal titanium because of its light weight, relatively high tensile strength, and excellent resistance to corrosion is an excellent bonding agent for diamond, and a tool properly bonded with this metal eliminates the aforementioned difficulties. However, because of its high melting point (1800° C.), its affinity for the ordinary gases, oxygen, nitrogen, and hydrogen, and its reaction with most refractories and carbon at high temperatures, the working of titanium offers numerous problems. The melting of titanium in graphite causes the absorption of carbon by the metal and results in embrittlement. The preparation of titanium-bonded diamond tools by ordinary sintering methods is not possible because of the pyrophoric nature of the titanium metal powder and its affinity for gases. Absorption of gases results in spot hardness and brittleness. Neither is it possible to vacuum-cast a matrix of titanium metal around diamonds because the diamonds, being lighter, float to the top. Temperature of 950° to 1000° C. result in graphitization of diamond.

It is possible to produce a tool in which diamond is embedded in titanium metal by sheath-rolling, as disclosed in my aforementioned application, Serial No. 222,130, but this method requires that the composition of diamond and powdered titanium metal powder be rammed into a metal tube which is then sealed to exclude detrimental gases and alternately heated and rolled to the proper size and shape. This method affords no means whereby the proportion of diamond at the face of the cutting tool may be greater than that in the body or shank of the tool, and provides no means for mounting the tool upon a shaft.

An object of this invention is to provide, a lightweight, metallic, corrosion-resistant, non-magnetic, titanium bonded diamond tool which may be mounted upon a shaft.

Another object of this invention is to provide a cutting tool having a face portion of titanium-bonded diamond and a shank portion of titanium metal.

A further object of this invention is to provide an improved method for making a titanium bonded diamond tool.

Other objects and advantages of this invention will be apparent from a consideration of the following description taken in connection with the accompanying drawings wherein:

Fig. 1 is a view of assembled portions of the tool of this invention in position in a welding machine for bonding into an integral structure.

Fig. 2 is a vertical section of the face portion of the tool prior to its assemblage into the completed structure.

Fig. 3 is a vertical section of a shank portion of the tool prior to its assemblage into the completed structure.

Fig. 4 is an elevational view, partially in section, of the completed diamond-faced titanium-bonded tool.

In a particular embodiment of the invention, and referring now to the drawings, the diamond-faced titanium-bonded cutting tool comprises a body or shank portion 10 of titanium metal having a head or face portion 12 consisting of diamond dust bonded with titanium metal. The shank portion of the tool may be hollow as at 14 so that it may be threaded or otherwise fitted upon a shaft.

The method for producing the titanium-bonded diamond tool, in general, comprises compressing a mixture of diamond dust and titanium powder to form a thin disc 12 (shown separately in Fig. 2), forming a plurality of apertured discs 16 of titanium metal by compressing titanium metal powder (shown separately in Fig. 3), superimposing the titanium metal discs upon the diamond-titanium disc (as shown, for example, in Fig. 1), and applying pressure and substantially instantaneous heat to the superimposed discs to bond them into a strong integral structure.

The invention will be understood more thoroughly in the light of the following description of an illustrative example of practice:

Example

Diamond powder of 600 mesh particle size is wet by the addition of a small amount of a suitable volatile hydrocarbon, such as tetrahydronaphthalene, and is intimately mixed by stirring with 200 mesh titanium metal powder. The titanium powder preferably has been hydrogen reduced and degassed. The proportions may be, for example, 98 per cent titanium metal powder and 2 per cent diamond dust. This mixture is placed in a suitable metallic die (not shown) and compressed to form a disc, designated as 12 in the drawings. A pressure of about 5000 pounds per square inch is satisfactory although much greater pressures may be used.

A plurality of discs 16 are produced in a similar manner, but of titanium powder only. A die is used which will provide a central aperture 18 (Fig. 3) in the titanium metal discs 16. A pressure of 5000 p. s. i. or more may also be used in forming these discs.

The titanium discs 16 are assembled, are superimposed upon the diamond containing disc 12, and the assembled discs are inserted in a small ceramic cylinder 20, which may, for example, be about two inches long. A small rod 22 of Pyrex glass or other suitable material is inserted through the center apertures 18 of the titanium metal discs 16. This assembly is then placed in a holding die 24, and beryllium-copper electrodes 26 and 28 of the same diameter as the discs are inserted into the top and bottom, respectively of the ceramic cylinder 20. One electrode is provided with a centrally located hole 30 to allow for movement of the Pyrex rod 22 when the discs are compressed and heated.

By means of an electric-resistance welder or other suitable means (not shown) current and pressure are applied simultaneously to the electrodes 26 and 28, and the discs are sintered and welded together in one operation. Upon removal of the bonded article from the apparatus, a diamond faced tool as shown in Fig. 4 is provided.

The short period of time during which electrical current is applied, for example, from one-tenth to one-half second, prevents the graphitization of the diamond at the high temperature instantaneously produced, and the relatively high pressure simultaneously applied, as for example, 5000 to 18,000 p. s. i., compacts the semi-plastic metal to an extent sufficient to hold the diamond particles firmly within the metal structure.

The electric-resistance welding machine utilized for applying the current and pressure to the electrodes may be

of any suitable type capable of exerting the necessary pressure and of supplying the current required for heating to the temperatures involved. It is important, however, to note that in the operation of the present invention, use is made of copper-beryllium electrodes for insertion in the mold, rather than of graphite, thereby avoiding absorption of the latter by the titanium metal.

The method and tool of this invention enables the use of finer particles of diamond dust than normally employed in diamond cutting tools since the titanium metal because of its hardness and resistance to wear holds the abrasive particles with greater tenacity than metals previously used. Thus, diamond dust of 600 mesh or finer may be employed, although, obviously, coarser material could be used as well. The finer sizes of diamond are preferred because they are more plentiful. The titanium metal powder is preferably of about 200 mesh or finer.

The proportions of titanium metal powder to diamond dust combined for the cutting disc are obviously variable depending upon the results desired. A satisfactory cutting tool may be made using proportions of titanium metal powder 98 per cent and diamond powder 2 per cent, although other proportions up to 50 per cent or more of diamond powder may be used. If desired, more than one or all of the discs bonded to make the integral tool may incorporate diamond dust thereby providing a deeper grinding portion.

The discs 16 forming the shank portion of the tool while preferably formed with a central aperture which when bonded together provide a hollow shank which can be threaded or otherwise machined for mounting upon a shaft, may also be formed solid, if desired, and other means of mounting employed.

The method of making the titanium-bonded tool holds the diamond particles securely in a metal of high tensile strength, which has good resistance to corrosion and satisfactory hardness, combined with a porosity of less than one per cent. The tool is useful as a grinding disc for the finishing of glasses, ceramics, hard metals or alloys, or for drilling similar materials. It is particularly useful as a detal drill as it may be sterilized in steam without rusting.

It will be appreciated from a reading of the foregoing specification that the invention herein described is susceptible of various changes and modifications without departing from the spirit and scope thereof.

What is claimed is:

1. The method of making an abrasive article comprising forming a plurality of thin discs of titanium metal powder by compression, at least one of which contains diamond powder, superimposing the discs one upon the other with a disc containing diamond dust at one end of the assembly, and applying pressure and substantially instantaneous heat to the assembly to convert the titanium to semi-plastic state and compact the semi-plastic titanium to thereby bond the discs into an integral article.

2. The method of making an abrasive article comprising compressing a mixture of diamond dust and titanium metal powder to form a disc, forming a plurality of discs of similar shape and provided with central apertures by compressing titanium metal powder, superimposing the apertured discs upon the diamond-titanium disc, inserting a glass rod in the central opening through the discs, and applying pressure and substantially instantaneous heat to the assembled discs to convert the titanium to semi-plastic state and compact the semi-plastic metal to bond the dust and powder into a diamond faced, hollow-shanked article.

3. The method of making an abrasive article comprising compressing a mixture of diamond dust and titanium metal powder to form a disc, compressing titanium metal powder to form a disc of similar shape, assembling the discs in a ceramic cylinder, placing the cylinder in a die, inserting copper-beryllium electrodes into each end of the cylinder, and simultaneously applying pressure of about 5000 to 18,000 pounds per square inch to the powder and an electric current to said electrodes for about one-tenth to one-half second to thereby heat the titanium metal to semi-plastic state to weld said discs into an integral abrasive article.

4. The method of making an abrasive article comprising compressing a mixture of about 2 per cent diamond dust and about 98 per cent titanium metal powder at a pressure of at least about 5000 pounds per square inch to form a thin disc, compressing titanium metal powder under similar pressure to form a plurality of said discs, assembling the discs in a ceramic cylinder with the diamond-titanium disc at one end of the assembly, placing the cylinder in a die, inserting copper-beryllium electrodes into each end of the cylinder, applying a pressure of from about 5,000 to 18,000 pounds per square inch to said electrodes and substantially simultaneously passing a current through the compressed material between the electrodes to thereby heat the titanium metal to a semi-plastic state and to weld the metal particles into an integral article.

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