Sept. 2, 1952 J. A. THOMAS, JR 2,609,285

ABRASIVE ARTICLE

Filed Dec. 8, 1949

Fig. 1.

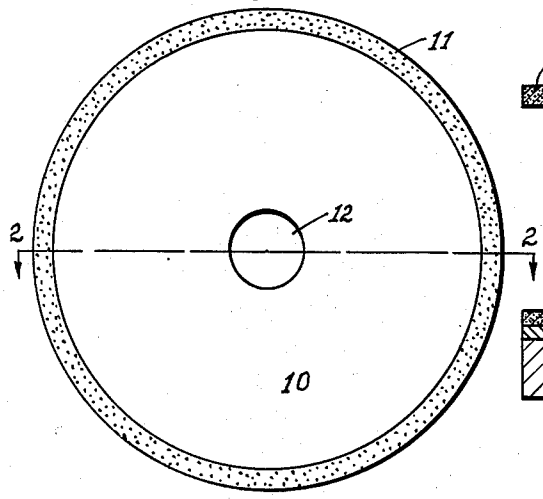


Fig. 2.

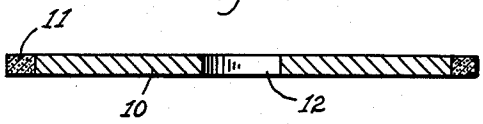


Fig. 3.

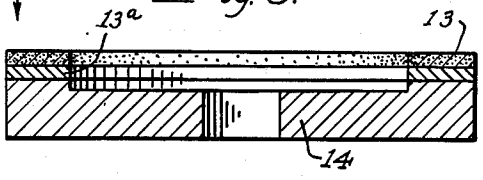


Fig. 4.

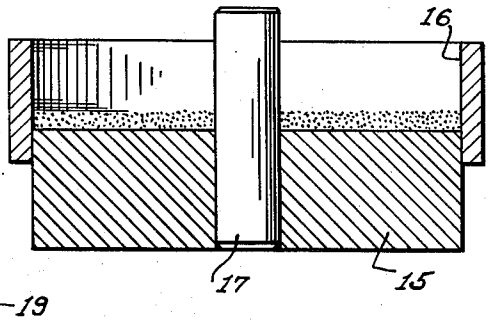


Fig. 5.

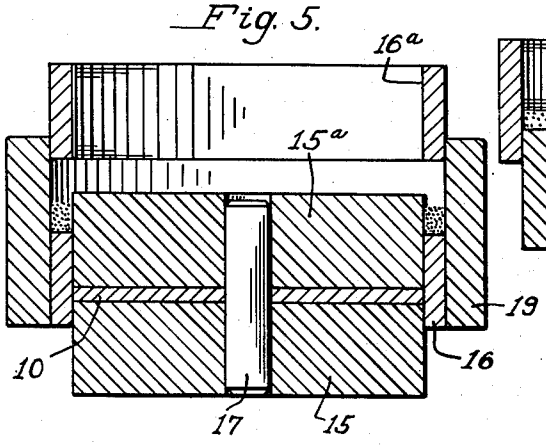
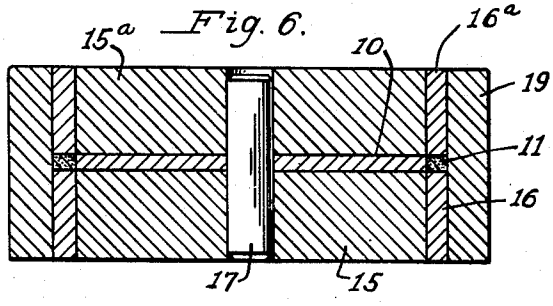


Fig. 6.



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ABRASIVE ARTICLE

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Application December 8, 1949, Serial No. 131,855

9 Claims. (Cl. 51—309)

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This invention relates to grinding wheels and specifically to grinding wheels utilizing a metal bond for diamond abrasive.

One object of the present invention is to provide a metal-bonded abrasive wheel in which the backing or supporting portion of the wheel is of different composition from that of the grinding portion. Another object of the invention is to provide a metal-bonded abrasive wheel which will be resistant to warping or distortion during sintering. Another object of the present invention is to make a metal-bonded abrasive wheel which will have a hard, rigid, metallic backing or supporting portion even though sintering is carried out at comparatively low temperatures. Still another object of the invention is to provide a metal-bonded abrasive wheel meeting the aforesaid objects and which can be obtained over a range of selected bond hardness. Other objects of the invention will be perceived from the following description thereof.

Many diamond abrasive wheels are so constructed that the diamond abrasive is contained only in that portion of the wheel where cutting is desired while the remainder of the wheel is composed only of or very largely of metal. In common practice the same metal is used for bonding the cutting portion and the backing or supporting portion of the wheel, the only difference being that in the cutting portion there is also abrasive. Such abrasive wheels are customarily produced from mixtures of metal powders, the backing or supporting portion being molded from metal powders alone or with small amounts of filler or lubricant and the cutting portion being molded from a mixture of the same metal powders and diamond abrasive, the two portions being then sintered into an integral body. The metal powders most generally used in the making of sintered diamond abrasive articles are copper and tin, the two metals being usually combined in proportions such as those in bronze.

It has been found that such metal bonded abrasive wheels have a tendency to distort or warp during sintering. It is believed that the tendency to distort, particularly in the case of wheels of substantial thickness, is caused by differential shrinkage occurring in the backing or support. As the temperature is raised during sintering the pressed metal powder of the wheel expands until the sintering temperature is reached. When sintering begins shrinkage occurs, with the top of the wheel being free to shrink somewhat more than the bottom thereof since the

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bottom of the wheel is, during sintering, in contact with a plate or bat and the friction between the bottom of the wheel and the bat tends to retard shrinkage. Another possible cause of distortion or warping in some cases is the difference between the expansion and contraction of the backing or support of the wheel and of the abrasive portion thereof. This is a result of the fact that the abrasive portion and the backing or supporting portion are not the same even though the same alloy is used since the abrasive portion has its coefficient of expansion and shrinkage characteristics modified by the presence of the abrasive.

According to U. S. Patent Application Serial No. 658,976, filed April 2, 1946, by Albert L. Ball and Carl G. Rose, now U. S. Patent No. 2,506,556, it was found that grinding wheels which were practically free of distortion or warping could be produced if the backing or supporting portion of the wheel was formed from a metal powder or a mixture of metal powders which produced at sintering temperatures a strong metal body without ever becoming sufficiently plastic to permit differential shrinkage. This result was obtained with abrasive wheels in which the bond for the abrasive was formed primarily from copper and tin powders, for example bonds such as are disclosed in Boyer Patent No. 2,137,329, issued November 22, 1938, by employing iron powder or a mixture of about 80–90% iron powder together with 8–18% copper powder and 1–4% tin powder. These sintered powdered metal compositions when used as the backing or supporting portion of the abrasive wheel require firing at a temperature in the neighborhood of 800° C. in order to develop a satisfactorily high sintered strength. While such a firing temperature requirement was found to be suitable in making wheels of a certain grade of hardness wherein the bond for the abrasive portion of the wheel contained 10% or less of tin it was found that when the bond for the abrasive portion of the wheel contained the greater amounts of tin in the neighborhood of 15–20% needed for the making of abrasive wheels having a harder grade, the firing temperature of 800° C. caused a bloating or puffing of the bond composition to a point where the bond was not acceptable. Attempts to overcome this difficulty by firing the grinding wheels at lower temperatures resulted in an undesirable lowering of the strength of the supporting center of the wheel to the point where the resulting wheel was no longer useful for many applications.

In accordance with the present invention, it

has now been found that satisfactory grinding wheels which are practically free of distortion or warping can be produced in the harder grades, as well as in the softer grades, by using a mixture of iron, copper and tin powders for the backing or supporting portion of the wheel in which the percentage of iron powder can be varied between about 50% and 75% by weight, the percentage of copper powder varied between 20% and 40% by weight and the percentage of tin powder varied between 5% and 10% by weight. It has been further found that the tensile strength of the non-abrasive backing or supporting portion of the wheel can be still further increased by the incorporation of approximately 2% by weight of a phosphorous-copper powder in the composition of the sintered metal backing or support. The sintered metal compositions employed for the non-abrasive supporting portion of the grinding wheels in carrying out the present invention are fired at a temperature in the neighborhood of 650° C. with the development of highly satisfactory tensile strengths. A phosphorous-copper alloy powder which has been found satisfactory is that sold by the Metals Disintegrating Company of Elizabeth, New Jersey, as phos-copper No. MD8685 containing 7–9% phosphorous. The aforesaid compositions produce the desired satisfactory results, namely, high strength, freedom from distortion and warping, and development of high strength at firing temperatures as low as 650° C., when used in the non-abrasive supporting centers or backings of grinding wheels in which the bond for the abrasive is formed primarily from copper and tin powders containing as high as 20% tin, for example, bonds such as are disclosed in Boyer Patent No. 2,137,329, issued November 22, 1938.

Table I below shows the physical test results obtained with sintered metal compositions composed of 200 mesh size iron powder, copper powder, tin powder and a phosphorous-copper alloy powder containing 7–9% phosphorous. The results shown were obtained on 1½" x ½" x ¼" test bars molded at 45,000 p. s. i. and sintered at 650° C. for 1½ hours.

TABLE I

Composition				Percent Shrinkage	Transverse Strength	Rockwell F Hardness
Percent By Weight			Added Parts By Weight Of Phos-Copper			
Iron	Copper	Tin				
90	8	2	2	0.04	41,500	65
85	12	3	2	0.06	42,000	68
80	16	4	2	0.06	48,200	71
75	20	5	2	0.10	48,800	75
70	24	6	2	0.13	54,000	77
65	28	7	2	0.17	58,100	80
60	32	8	2	0.24	61,700	82
55	36	9	2	0.23	64,200	85
50	40	10	2	0.30	57,800	87

A study of the above table will show that the transverse strength is greatest in those compositions where the percentage of iron is between 50% and 75%, the percentage of copper is between 20% and 40%, and the percentage of tin is between 5% and 10%. It is also noted that the per cent shrinkage increases as the percentage of iron is decreased. It was found that compositions containing less than 50% iron powder were completely unsatisfactory because of excessive shrinkage. The presence of more than 75% iron with correspondingly lower percentages of copper and tin requires a firing in the neighborhood of 800° C. to develop high strengths.

Omission of the phosphorous-copper from the compositions set forth in Table I above results in a lowering of the transverse strength by approximately 5,000 pounds although its presence appears to have no effect upon the shrinkage characteristics of the compositions.

One particular composition which has been found to be highly satisfactory as the sintered metal backing or supporting portion of a grinding wheel where the bond for the abrasive portion is composed of 82% copper powder and 18% tin powder, and which can be fired to adequately highly sintered strength at a temperature of 650° C. is composed as follows:

Percent By Weight	Parts By Weight	
53.9	55	200 Mesh size Iron Powder.
35.3	36	Copper Powder.
8.8	9	Tin Powder.
2.0	2	Phos-Copper Powder (Containing 7–9% phosphorous).

In the drawing, Figure 1 represents a plan view of a peripheral grinding abrasive wheel.

Figure 2 represents a section on line 2—2 of Figure 1.

Figure 3 is a sectional view of a face grinding abrasive wheel of the so-called "cup" type.

Figures 4, 5, and 6 illustrate steps in the molding of a diamond abrasive wheel such as that shown in Figures 1 and 2.

The metal powders used in carrying out the present invention may be of the commonly available commercial types and should be comparatively pure to permit regulation of the extent of alloying by adjustment of the sintering temperature and time. Such metal powders are preferably of 200 mesh and finer size.

The molding of a peripheral grinding wheel of the type shown in Figures 1 and 2 in which a metal core or backing 10 surrounds an arbor hole 12 and has formed integrally therewith an abrasive rim 11 is shown in Figures 4, 5, and 6. In Figure 4 a mold block or plunger 15 is provided with a central pin or plug 17 and a closely fitting mold ring 16. A mixture of iron, copper, and tin powders in an amount calculated to be sufficient to make a wheel center of the desired thickness is then placed on plunger 15 in the cavity formed by the ring 16 and pin 17 and is spread evenly therein.

Upper mold plunger 15*a* is then put in place and consolidating pressure which may be as high as 15,000 to 20,000 p. s. i. is applied to the plungers 15 and 15*a*. After this preliminary consolidation of the backing or support there is placed around mold ring 16, as shown in Figure 5, an outer mold ring 19 and the mixture of diamond abrasive and metal powder needed for the abra-

sive rim is spread evenly in the space between plunger 15a and mold ring 19. An upper ring 16a is then inserted into the assembly in such position that it will operate to compress the abrasive mix against ring 16 and the whole mold assembly is again subjected to pressure. As shown in Figure 6, the abrasive rim and the backing or support are brought together into line as the mold is closed and suitable pressure which may in some cases be as much as 50,000 to 75,000 p. s. i. or more is then applied. The effect of this pressure is to cause unification of the abrasive rim and the metallic backing or supporting portion so that the pressed wheel may be handled as an integral body without danger of separation.

In Figure 3 there is shown a sectional view of a form of abrasive wheel which is intended for grinding on the face or sides. Here the cutting portion 13 molded from a mixture of abrasive and metal powders is formed integrally with a backing or supporting portion 13a which, in accordance with the present invention, is molded from a mixture of iron, copper and tin powders. The molding may be carried out, so far as the mechanical procedure is concerned, in accordance with known practice. Rings 13 and 13a, after sintering, are attached to a mounting 14 by any suitable means. Mounting 14 may be constructed of any desired material, for example metal or resinoid and may also, of course, be of any desired shape or configuration with such provision for installation on a grinding machine or spindle as is necessary.

After removal from the mold, abrasive wheels made in accordance with the present invention may be sintered in any convenient or desired manner. A simple and effective manner is by supporting the wheel on a bat or plate and placing it in a heated furnace having a reducing or non-oxidizing atmosphere. The wheel is kept in the furnace for the necessary period of time to obtain thorough sintering, the hardness of the bond being determined largely by the temperature at which the sintering is carried out. This is well known in the art and the hardness may be regulated as desired.

In the foregoing description abrasive wheels of the type shown in Figures 1 and 2 have been described as having a metal support or core which extends from the abrasive peripheral rim to the arbor hole. It will be realized that with large wheels the amount of metal in such a construction will be large and accordingly the weight of the wheel will be excessive. With large wheels, therefore, it will frequently be desired to have the metal core or support extend inwardly from the abrasive rim only a relatively small distance, of the order of 1 to 18 times the thickness of the abrasive rim depending on the size of the wheel, and to have the rest of the core or support formed from some lighter material such as a moldable plastic which can be attached in any suitable manner to the metal support or which may be molded in situ inside the metal supporting ring. Wheel constructions of this type are intended to be within the scope of the present invention since the advantages of the present invention are inherent therein even though the entire support is not formed of metal.

The proportion of diamond employed in the abrasive rim of the wheel is not critical and will vary with the purpose for which the wheel is intended. Other types of abrasives might be used instead of diamonds although it has been found that except in very rare cases the expense of metal bonds is not warranted except for an expensive abrasive such as diamond. However, so far as the present invention is concerned, it will be operative with and it is intended to cover abrasive wheels made with all types of abrasive materials such as alumina, silicon carbide, boron carbide, emery, titanium carbide, and the like.

Furthermore although the invention has been described with particular reference to bonds obtained by sintering mixtures of copper and tin powders, it is applicable also to bonds of that type containing other alloying elements such as iron, nickel, zinc, aluminum, etc.

Where the term "support" is used in the claims it is intended to include and be broad enough to cover backings and other integral sintered supporting members. Where percentages are specified in the claims they are percentages by weight.

It will be understood that there are many other obvious changes and variations that may be made in the method of carrying out the invention which has been described above and it will be understood that all such variations and changes are meant to be comprehended within the present invention and that the invention may be utilized in producing abrasive articles other than wheels. It is not intended that the invention shall be limited except by the scope of the following claims:

I claim:

1. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of diamond abrasive particles and a bond comprising the sintered reaction product of a major proportion of copper powder and tin powder in an amount up to about 20% of the weight of said bond, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 50–70% iron powder, 24–40% copper powder and 6–10% tin powder.

2. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of diamond abrasive particles and a bond comprising the sintered reaction product of a major proportion of copper powder and tin powder in an amount up to about 20% of the weight of said bond, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 50–80% iron powder, 16–40% copper powder, 4–10% tin powder and containing approximately 2% by weight of the bond of phosphorous-copper.

3. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of abrasive particles and a bond comprising the sintered reaction product of a major proportion of copper powder and tin powder in an amount up to about 20% of the weight of said bond, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 50–70% iron powder, 24–40% copper powder and 6–10% tin powder.

4. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of abrasive particles and a bond comprising the sintered reaction product of a major proportion of copper powder and tin powder in an amount up to about 20% of the weight of said bond, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 50–80% iron powder, 16–40% copper powder, 4–10% tin powder and containing approximately 2% by weight of the bond of phosphorous-copper.

5. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of diamond abrasive particles and a bond comprising a sintered reaction product of a major proportion of copper powder and tin powder in an amount up to about 20% of the weight of said bond, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 54% iron powder, 35% copper powder, 9% tin powder and 2% phosphorous-copper powder.

6. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of diamond abrasive particles and a bond comprising the sintered reaction product of a major proportion of copper powder and tin powder in an amount up to about 20% of the weight of said bond, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 55% iron powder, 36% copper powder and 9% tin powder.

7. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of abrasive particles and a bond comprising the sintered reaction product of a major proportion of copper powder and tin powder in an amount up to about 20% of the weight of said bond, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 54% iron powder, 35% copper powder, 9% tin powder and 2% phosphorous-copper powder.

8. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of diamond abrasive particles and a bond comprising the sintered reaction product of approximately 82% copper powder and 18% tin powder, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 50–70% iron powder, 24–40% copper powder and 6–10% tin powder.

9. A metal-bonded abrasive article comprising a sintered abrasive portion containing a minor proportion of diamond abrasive particles and a bond comprising the sintered reaction product of approximately 82% copper powder and 18% tin powder, and an integral, sintered, non-abrasive metal support for said abrasive portion comprising in sintered form about 50–80% iron powder, 16–40% copper powder, 4–10% tin powder and containing approximately 2% by weight of the bond of phosphorous-copper.

JAMES A. THOMAS, JR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,506,556	Ball et al.	May 2, 1950