Nov. 9, 1943. E. VAN DER PYL 2,334,049

CUP SHAPED ABRASIVE WHEEL AND METHOD OF MAKING THE SAME

Filed Dec. 1, 1941

Fig.1

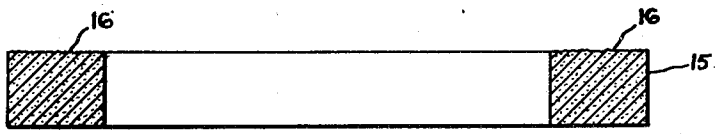


Fig.2

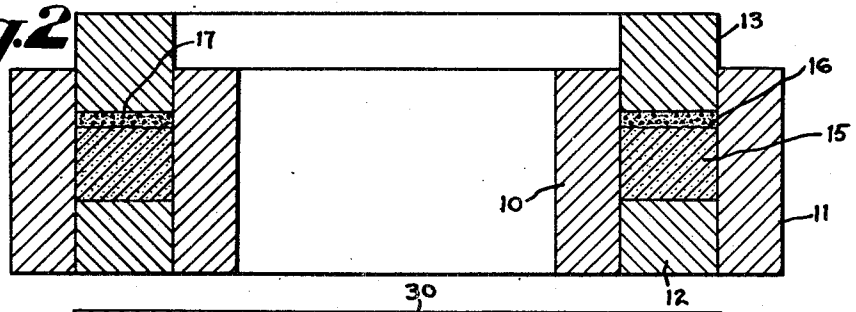
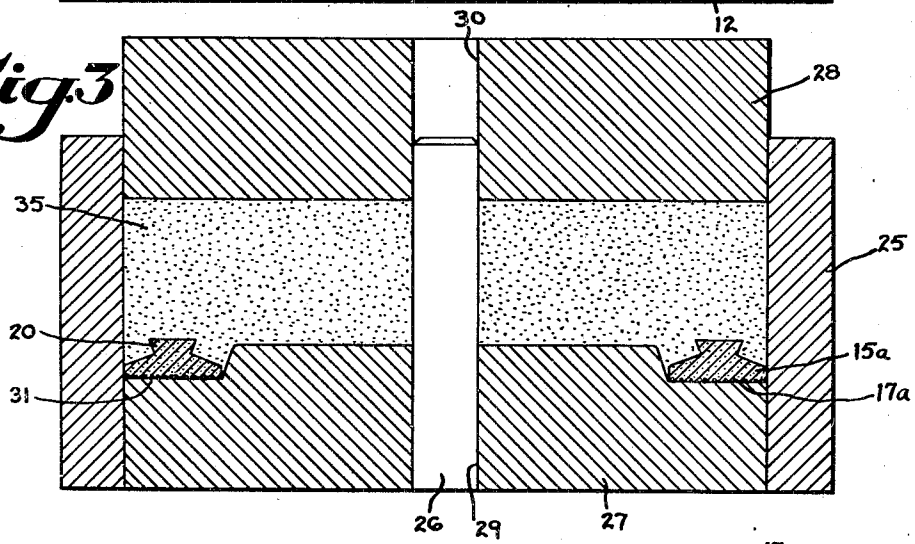


Fig.3



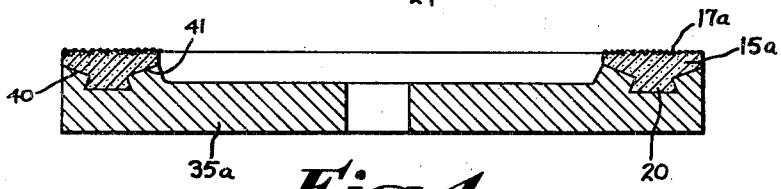


Fig.4

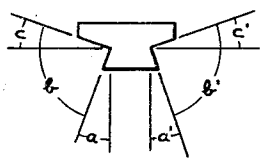


Fig.5

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2,334,049

CUP SHAPED ABRASIVE WHEEL AND METHOD OF MAKING THE SAME

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Application December 1, 1941, Serial No. 421,151

6 Claims. (Cl. 51—209)

The invention relates to abrasive wheels which grind on an annular face thereof, including cup wheels and dish wheels and a method of making the same, and with regard to its more specific features relates to diamond abrasive wheels and methods of manufacture thereof. This application is a continuation in part of my copending application Serial No. 264,787 filed March 29, 1939.

This application discloses and contains certain subject matter common to it and my co-pending application, Serial No. 421,152, filed concurrently herewith, which discloses other species of my invention, and it is in my said co-pending application that such subject matter common to all species is generically claimed.

One object of the invention is to provide a simple and expeditious method for the manufacture of wheels of the class indicated whereby all the diamonds are concentrated in the usable portion. Another object of the invention is to make a light weight cup-shaped metal bonded diamond grinding wheel. Another object of the invention is to provide an extremely hard diamond abrasive wheel with ample provision for dissipating the heat of grinding, yet of light weight construction.

Another object of the invention is to provide a simple and effective method for the manufacture of abrasive articles of the type mentioned above. Another object of the invention is to provide a built-up grinding wheel construction that will be capable of efficient and low cost manufacture and that will be strong, durable and efficient in action. Another object of the invention is to provide an effective method for the building up of a composite type of grinding wheel construction that may be readily and efficiently carried on in practice and that provides for facile and reliable control of forces or stresses occurring in parts of the built-up wheel construction during its fabrication, to effect strong and lasting junctions between the parts. Other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts, and in the several steps and relation and order of each of said steps to one or more of the others thereof, all as will be exemplified in the structure to be hereinafter described, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing illustrating one of many possible embodiments of the mechanical features of this invention, Figures 1 to 4 are axial sectional views, in which:

Figure 1 shows a lightly compacted metal ring formed from metal powders;

Figure 2 shows a mold charged with the metal ring of Figure 1 and with some abrasive and bond;

Figure 3 shows a mold construction for carrying out the step of pressing the resinoid backing or support onto the metal ring;

Figure 4 shows the completed article; and

Figure 5 is a geometrical representation showing the relationship of certain surfaces.

Referring first to Figure 2, I provide a mold, such as the mold illustrated therein. This mold comprises an inside mold ring 10, an outside mold ring 11, an annular bottom plate 12, and an annular top plate 13 fitting together, as shown. I fill such a mold with a precalculated quantity of metal powders which, when pressed under the appropriate pressure, will produce an annular disk or ring 15 (Figure 1) of the desired thickness. This ring 15 is pressed at low pressure, that is to say, with from four to eight (short) tons to the square inch. By weighing out a predetermined quantity of metal powders and pressing at a given pressure, a ring 15 of substantially predetermined size can be produced.

After the ring 15 is pressed, it is removed from the mold and roughened up on one flat surface, for example, the surface 16, Figure 1. This may be done by sandblasting or by lapping with loose, coarse abrasive grain, such as fused alumina. The disk 15 is then replaced in the mold with the surface 16 uppermost. Upon this surface 16 is then spread a mixture 17 of diamonds and powdered metal bond, preferably of the same metal or combination of metals from which the ring 15 was formed.

Considering now illustrative metals to be used, I may use any one of nickel, aluminum, aluminum-silicon, iron, iron with carbon or other alloying ingredients used in various steels, but especially I prefer copper and copper alloys. A brittle bond of the order of 18% (by weight) tin and the remainder copper is especially useful for some purposes. I may use other bronzes containing manganese, aluminum, nickel or beryllium. Or I may use equal parts by weight of copper, tin, nickel and iron. The metal bonds that I prefer are described in my prior U. S. patents, Reissue No. 21,165 and No. 2,238,351. Usually pure metal powders will be used since the sintering operation forms the alloy, but alloy powders may be used.

The proportion of diamonds by volume to metal bond in the ultimate abrasive layer 17a may be varied widely, but 25% by volume of diamonds

on the whole composition of diamonds and metal bond is a good proportion.

I now reinsert the mold ring 13 and again place the mold in a hydraulic press and press, this time to a pressure of the order of 25 to 50 (short) tons to the square inch. I then remove the annular disk 15 with its abrasive layer 17a and sinter it at a suitable sintering temperature, below the fusing point of the metal or final alloy. For a copper-tin mixture, 18% tin and 82% copper, a satisfactory sintering temperature is 600° C. The ring 15 with its layer of abrasive and metal 17a should be kept at this sintering temperature of 600° C. for around two hours. It is preferable to sinter in a neutral atmosphere.

The above-described sequence of steps is illustrative of those that I prefer to employ where the abrasive grains are metal-bonded and where the grinding wheel is to grind on a side face and hence where the stress imposed by the grinding action upon the ultimate support for the ring-like abrasive element is in a direction generally paralleling the axis of the grinding wheel; for an illustrative and preferred sequence of steps to make up a ring-like abrasive element that has its abrasive portion on an outer or peripheral face and hence where the reaction from the grinding operation upon the center or support for the ring-like member is in a general radial direction, reference may be made to my above-mentioned co-pending application, Serial No. 421,152.

Following the sintering operation, I machine the annular member or ring 15 on that face or portion thereof at which it is to be attached to the center or support, and in this illustrative embodiment I hence machine the abrasive-carrying-ring on that face thereof that is juxtaposed to the abrasive portion 17a to give it a shape preferably as shown at 15a in Figures 3 and 4. The ring 15a, when so machined, now comprises a single annular dovetail 20. Referring to Figure 5, the angle *a* is preferably of the order of 20 degrees, while the angle *b* is preferably substantially 90 degrees. This makes the angle *c* also 20 degrees. While these angles are not exactly critical, I find that I am enabled to form, as hereinafter illustratively set forth, a resinoid back on the ring 15a without trouble from shrinkage of the resin during curing owing to the tapering form of the under side of the ring 15a with the sharp taper described. A single dovetail, as shown, makes a stronger construction than a plurality of dovetails but my invention is not to be limited to a single dovetail arrangement excepting where such of the claims herein specifically call for a single dovetail.

The thus prepared metal ring 15a, with the attaching portion that comprises the annular dovetail 20, and the integral abrasive portion 17a is then placed upside down in the mold of Figure 3. The mold of Figure 3 comprises an annular cylindrical mold ring 25, a central arbor or plug 26, a shaped bottom plate 27, and a cylindrical top plate 28. The bottom plate 26 and the top plate 28 have central holes 29 and 30 in which fits the arbor 26 with a press fit.

Having placed the bottom plate 27 and the arbor 26 in the mold ring 25 and having placed the ring 15a upside down in the annular depression 31 in the bottom plate 27, I fill the space above the ring 15a and bottom plate 27 with what I term an "uncured resinoid mix," such as a mixture 35 of powdered uncured resinoid and some inert material. A powdered "A" stage resin with a suitable hardening agent therefor may be used and, for the inert material, asbestos filler is illustrative and satisfactory. The resinoid preferably is phenol formaldehyde, desirably with hexamethylene tetramine as a hardening agent, but other resins may be used, for example any of the alkyd resins or aniline formaldehyde. I now place the top plate 28 in position, as shown in Figure 3. I then place the entire mold of Figure 3 in a hot press and press with a pressure of the order of 6000 pounds to the square inch for one and one-half hours at 160° C. The specific pressure-temperature-time figures are given for phenol formaldehyde resin. Other resins may require different curing conditions but such are understood in the resin molding art.

The initial volume of the resin mixture 35 (see Figure 3) may be of the order of three times the final volume of the cured backing 35a (see Figure 4), especially when light, fluffy filler is used, such as asbestos. I find that by proceeding as set forth, a strong integral article is formed despite the tendency of resin undergoing curing to shrink from objects to which it is molded. As the resin shrinks against the under side of the ring 15a, the angle *c* causes it to draw into tight engagement with the dovetail 20 and at the same time the taper of the ring 15a on the under side prevents the formation of any crack between the parts 15a and 35a.

The article of the invention has a diamond abrasive portion 17a which as actually manufactured in one embodiment has a depth of about one thirty-second of an inch. When the article is used to grind the cemented carbide cutting tools and considerable pressure is applied, the heat generated at the grinding line is rapidly conducted away by the metallic backing 15a. The wheel shown in the illustrative embodiment makes an excellent wheel for forming and sharpening cemented carbide cutting tools and the bond can be hard so that the wheel wears for a long time. Consequently a sharp pointed tool can be placed on the grinding surface 17a without ripping a hole in it. Nevertheless about the time the diamonds have become dull at the corners, a minute chunk or fragment of the bond will break out, thus allowing a diamond to fracture or be removed. In actual practice, the above-mentioned illustrative wheel has been found to be able to cut any material and to be extremely wear resistant, it being understood that considerable grinding pressure should be used on account of the hardness of the bond. A friable bond is desired rather than a ductile one and also for the best results the metal backing 15a should have no abrasive, that is to say, no non-metallic material. In connection with the last statement, it will be understood that insignificant amounts of foreign materials would do no particular harm and so would not take an article outside of the scope of the present invention. That is to say, the metal backing portion 20 should be at least 95% metal. The just-stated factors are descriptive of one embodiment of grinding wheel as I prefer it for the grinding of cemented carbides as illustratively mentioned above and they are not to be interpreted by way of limitation excepting as to such of the following claims as are specifically limited to these factors or features.

It will be seen that by following the above-described illustrative steps for applying the diamond abrasive portion 17a to the face 16 of the ring 15, the abrasive layer 17a may be made exceedingly thin if desired, and may comprise substantially a single layer of diamonds. But in

most cases it will be found desirable to form a metal bonded abrasive portion 17a having many layers of diamonds. Commercial sizes now made have a diamond depth of 1/32", 1/16" and 1/8", respectively. The life of the wheel is a function of the depth of the abrasive portion.

While diamonds have been specifically mentioned, other abrasive could be used, for example, fused alumina in any of its forms, including emery, corundum, fused alumina, also silicon carbide or any other hard carbide including boron carbide and carbide mixtures, particularly fusion products of carbide mixtures. Also, other resins than those mentioned could be used for the back 35a, for example, methyl methacrylate, styrene, shellac or rubber.

Also, it is within the scope of this invention to form an article in which the abrasive surface is other than on a face of ring 15a whose plane is at right angles to the axis of the wheel, for example the abrasive surface 17a can be a frusto conical surface "dished inwardly" or, geometrically speaking, an interior conical surface, or it can be frusto conical "dished outwardly," that is, geometrically speaking, an outer conical surface. In the transition and at a particular angle either the surface 40 or the surface 41 may be changed to a plane or a cylinder and thus the same relationship between the surface 17a and the surfaces 40 and 41 may, if desired, be maintained so far as their generatrices are concerned. These surfaces 40 and 41 are generated by a pair of lines which intersect in the dove tail 20 and which lines strike the surface of the abrasive surface 17a outside thereof, that is to say they strike the abrasive surface extended in acute angles. These angles are the same as the angles c, c' in Figure 5 and these angles are preferably between 15 and 45 degrees in order to form a tight union. The angle b is shown as 90 degrees but it might be more or it might be less. The angle a is preferably at least 15 degrees to provide good interlocking but may be considerably larger so long as the angle b is maintained of sufficient size, illustratively and preferably at least 45 degrees. Thus the same differences preferably likewise hold for the angles a', b' and c', Figure 5.

The just-described arrangements for the several angles to each side of a vertical central axis as viewed in Figure 5 will be seen, from both Figures 5 and 4, to make it possible, where desired, to have substantial symmetry of angularities to either side of such a vertical axis and the two sets of re-entrant angularly inclined surfaces that form, respectively, the angles b and b' will be seen to face in opposite directions, thus more certainly to coact with the stresses or forces, and their various possible directions, within the resinoid during curing. For example, and referring to Figures 4 and 5, the stresses or forces within the curing resinoid can act in effect to substantially wedge or force the two portions of the resinoid more tightly into the respective recesses formed by the angles b and b', for, as above stated, I am enabled to prevent the formation of cracks at the junction between the parts 15a and 35a of Figure 4. In any event, there is a tight gripping or firm contact of the resinoid against the surfaces of the attaching portion of the metal ring 15a. The opposed relationship of the inclined surfaces forming the angles b and b' will be seen furthermore to have the advantage of being capable of coacting with stresses in the resinoid whether those stresses act predominantly inwardly along a radius or predominantly outwardly along a radius, for the recess or angle b of which the surface 40 is a part is so related, as is clear from Figure 4, that any inward radial movement of the resinoid portion results in pressing it more tightly into the angle b while recess or angle b' of which the surface 41 is a part will be seen, as is clearly shown in Figure 4, to be so related that any movement in outward direction along a radius of the portion of the resinoid received in that angle b' results simply in more tightly pressing it into engagement with the surfaces forming angle b'. In the illustrative embodiment, as above set forth, the stresses or forces within the resinoid act to press both of these portions of the resinoid into their respective angles b and b' because I have found, as above stated, that the formation of any cracks in the junction between the parts 15a and 35a of Figure 4 is prevented; thus it will be seen that I am enabled to make use of forces or stresses created in the resinoid undergoing curing, for taking part in effecting a reliable union or connection of the resinoid with the attaching portion of the metal ring; these forces or stresses result primarily from change, such as shrinkage in volume that the resinoid undergoes during curing.

It will thus be seen that there has been provided by this invention an article and a method in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As various possible embodiments might be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinbefore set forth or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. An abrasive wheel comprising a metal ring being, except for possible minor impurities, all metal in a base part and metal bonded abrasive in an abrasive part, the said two parts being integrally united and constituting a jointless unit, the abrasive part having a truly annular abrasive surface, a single annular dove tail formed on said base part opposite said annular abrasive surface, a pair of surfaces of said base part being generated about the axis of the wheel as a whole by a pair of lines which lines intersect in the dove tail and which lines strike the abrasive surface extended in angles of greater than 15 degrees and less than 45 degrees, and a cured organic backing molded on to said dove tail and in firm contact with the two surfaces generated by the pair of lines.

2. Method of making an abrasive wheel comprising forming a ring out of metal powders by pressing with a relatively light pressure, placing said ring in a mold and adding a mixture of comminuted abrasive and metal powder, again pressing with a substantially heavier pressure, then sintering the combined article thus produced to form an integral ring having an abrasive surface, then machining the ring to form an annular dove tail opposite said abrasive surface and a pair of surfaces on said ring generated about the axis of the ring as a whole by a pair of lines which intersect in the dove tail and which lines strike the abrasive surface extended in angles of greater than 15 degrees and less than 45 degrees, then placing the entire ring thus formed in a mold, filling the mold with uncured resin and

filler and pressing to compact the uncured resin and filler against the said pair of surfaces and around the annular dove tail and curing.

3. In a method of making an abrasive wheel that has a metal ring provided with an abrasive surface and an attaching portion, and a disk-like resinoid supporting member for said ring, the steps which comprise modifying the attaching portion of the metal ring to form thereon at least two surfaces that are at an angle to each other to form an open annular space which, because of the angle between said surfaces, is of substantially tapering cross-section, placing the modified ring and an uncured resinoid mix in a mold with said two surfaces and said annular space exposed to the resinoid mix in a direction related to subsequent stresses exerted in a radial direction by and within the mix to cause the resinoid to be forced in the general direction of a radius against said two surfaces and into said annular space of tapering cross-section formed between said surfaces, pressing them together to flow the mix into full supporting contact with and into the said space formed by said surfaces, and heating the mix to cure it and to cause the radially-acting stresses exerted within and by the curing resinoid to enter it progressively in the direction of a radius into said space of tapering cross-section to press annular portions of the resinoid against and in firm contact with said two surfaces.

4. In a method of making an abrasive wheel that has a metal ring that has an abrasive surface and an attaching portion presenting a ring-shaped face directed in the general direction of the axis of the wheel, the steps which comprise modifying the said face to form thereon opposed sets of re-entrant angularly inclined surfaces, placing the modified ring and an uncured resinoid mix in a mold with the said modified face exposed to the mix and with said opposed re-entrant angularly inclined surfaces exposed to the mix so that subsequent shrinkage of the mix forces the resinoid into the opposed angularities to grip the intervening material of the ring, pressing the mix in a general axial direction to flow the mix against said modified face and into the angularities of said opposed sets of re-entrant angularly inclined surfaces, and heating the curing the said mix to cause shrinkage of the latter to force the resinoid into said opposed angularities to effect gripping of the intervening portion of the ring.

5. An abrasive wheel comprising a metal ring having an abrasive portion and an attaching portion, and a disk-like resinoid supporting member for said ring, said attaching portion of the metal ring having thereon at least two surfaces that are at an angle to each other and form therebetween an annular space which, because of the angle between said surfaces, is of substantially tapering cross-section and which is open in a direction to coact directly with radially-stressed annular portions of said resinoid member, said disk-like resinoid supporting member having annular portions thereof entered into said space and respectively engaged with said two surfaces, the said surfaces being positioned relative to the radially-acting stresses exerted by and within the resinoid of said supporting member by and during curing to radially press the resinoid annular portions into said space of tapering cross-section to effect gripping engagement of said annular portions of the resinoid against said two surfaces.

6. An abrasive wheel comprising a metal ring having an abrasive portion and an attaching portion, and a resinoid supporting member for said ring, said attaching portion having a ring-shaped face facing in the general direction of the axis of the wheel and having in said face opposed sets of re-entrant angularly inclined surfaces with which said resinoid supporting member inter-engages, the said sets of re-entrant angularly inclined surfaces being positioned relative to each other and relative to the directions of shrinkage of the resinoid, during curing, of said resinoid supporting member to direct the forces of shrinkage to press portions of the resinoid, respectively, into the angles of the said opposed sets of re-entrant angularly inclined surfaces to thereby tightly seat said resinoid portions therein and to effect gripping thereby of the intervening portion of the metal ring.

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