April 28, 1942. L. H. MILLIGAN ET AL 2,281,525

GRINDING WHEEL

Filed Nov. 19, 1936

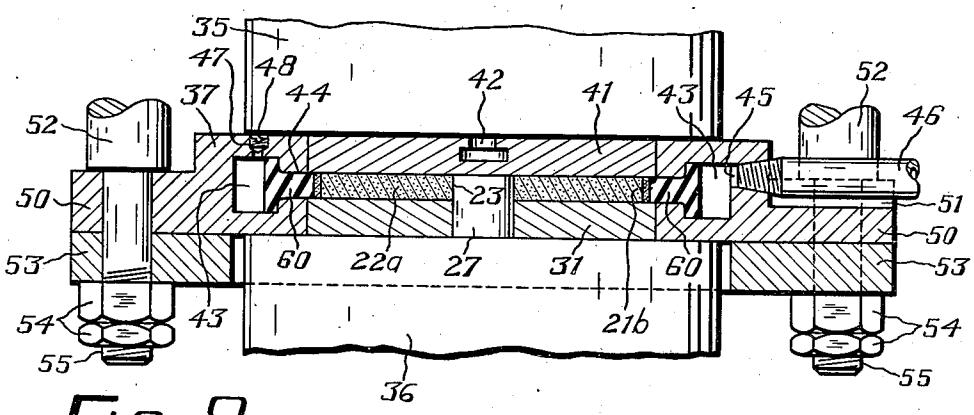


FIG. 8

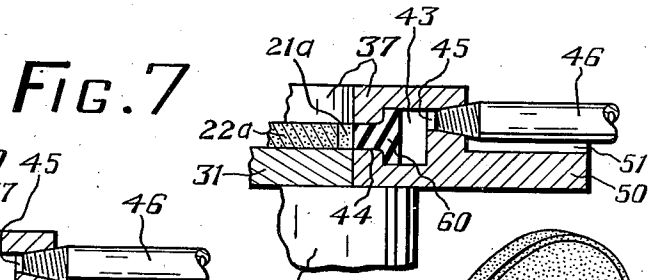


FIG. 7

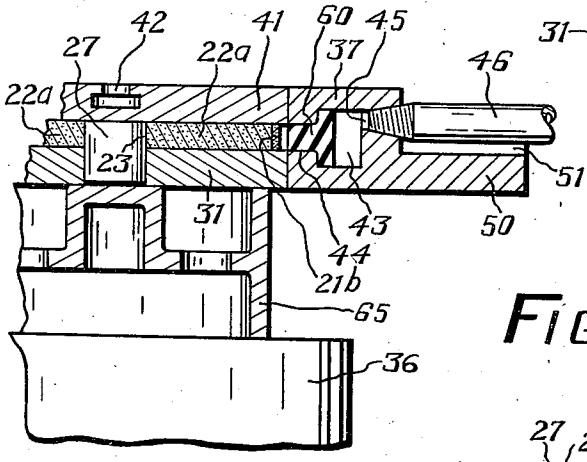


FIG. 9

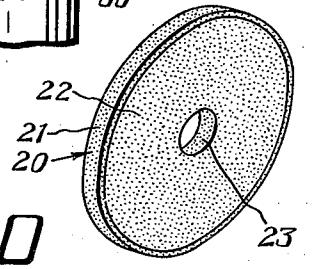


FIG. 10

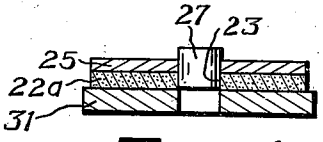


FIG. 4

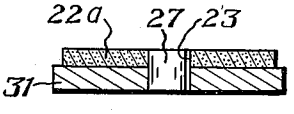


FIG. 6

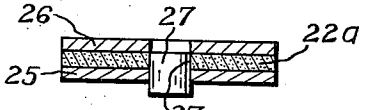


FIG. 2

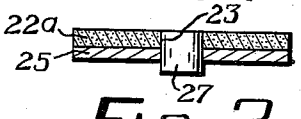


FIG. 3

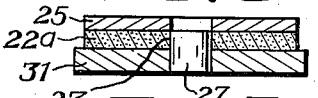


FIG. 5

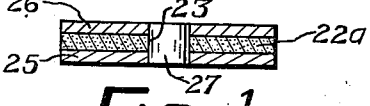


FIG. 1

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GRINDING WHEEL

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Application November 19, 1936, Serial No. 111,720

5 Claims. (Cl. 51—293)

The invention relates to grinding wheels and methods for the manufacture thereof, and with regard to its more specific features to the manufacture of diamond abrasive wheels bonded with vitrified ceramic bond.

One object of the invention is to provide a vitrified diamond grinding wheel of relatively large diameter and reasonable cost. Another object of the invention is to provide a method for the manufacture of an article of the class indicated. Another object of the invention is to permit the manufacture of a medium to large sized grinding wheel containing diamond abrasive at a reasonable cost, more especially using vitrifiable or ceramic bond. Another object of the invention is to make a grinding wheel of two-part construction which nevertheless acts as an integral unit so far as many physical characteristics are concerned. 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 illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawing in which is shown one of many possible embodiments of the mechanical features of this invention,

Figure 1 illustrates in radial section the top and bottom plates of a mold, the central plug thereof, and an interposed compressed disk of granular material and vitrified ceramic bond, all just after stripping from the mold ring.

Figure 2 is a view of the parts and material shown in Figure 1, with the central plug pushed downwardly and out of the top mold plate.

Figure 3 is a view similar to Figure 2, the top mold plate having been removed.

Figure 4 shows the foregoing parts turned over and a different bottom plate in position thereunder.

Figure 5 shows the next step comprising the pressing of the plug into the new bottom plate.

Figure 6 shows the parts after the erstwhile bottom plate has been removed.

Figure 7 is a fragmentary view illustrating a portion of the apparatus for the second molding operation and showing the assemblage of Figure 6 located therein.

Figure 8 is a radial cross section through the entire mold for the second molding operation and its supporting structure, showing also upper and lower hydraulic press plungers, being the same apparatus a fragment of which is shown in Figure 7, however Figure 8 showing a subsequent step in the method.

Figure 9 is a further fragmentary view of the apparatus of the Figures 7 and 8, but showing the upper hydraulic press plunger elevated and the mold for the second molding operation about to be stripped from its mold ring by the lower plunger of the hydraulic press.

Figure 10 shows the final product of the invention.

It will facilitate an understanding of the invention to refer first to Figure 10 which shows the ultimate product. This product is a grinding wheel **20** comprising an annular band **21** of diamond abrasive bonded with a suitable bond, preferably and according to many features of the invention vitrifiable ceramic bond, integrally united to a central disk **22** having a central hole **23**, which disk, so far as certain features of the invention are concerned, may be of any substance having adequate strength but, so far as the preferred form of the invention is concerned, comprises granular material bonded with ceramic vitrified bond, the entire wheel **20** being vitrified or burned in a kiln in a single firing operation. To produce this integral wheel **20**, the multi-stage molding and pressing operations herein disclosed and indicated in the drawing are preferably used. It is desired that the shrinkage characteristics of the diamond part **21** and the non-diamond part **22** be the same or as nearly alike as possible. It is further desired that the coefficient of expansion of the granular part in the part **22** be as nearly as may be the same as that of the diamonds in the part **21**, all in order that the finished product shall have physical characteristics as nearly as possible those of a monolith so as to avoid breakage in use or otherwise.

Diamonds to be used as abrasive grains in the manufacture of bonded abrasive products are so expensive as to limit their use, in products of relatively large size, to an exterior or peripheral zone that is to be actually employed for the grinding or cutting operation itself, and which peripheral zone can be completely used up with a minimum wastage, in the normal grinding operations for which the article is used. We have found that for many practical grinding operations diamonds can be most effectively bonded with a ceramic bond. Because diamonds are oxidizable, we prefer to use low firing temperatures. While the present invention is not limited to any specific bond, nevertheless in order to disclose the best

way now known to us of carrying our invention into actual practice, we note that the bond used may be such as disclosed in our prior copending application Serial No. 51,334 filed November 23, 1935. As therein disclosed, the bond for the diamonds may comprise the following:

Example I

Frit	Borax	32.2 lbs.	75 parts
	Boric acid	25.4 lbs.	
	Silica	37.6 lbs.	
	Hydrate of alumina	1.0 lbs.	
	Whiting	3.8 lbs.	
Ball clay			30 parts

or the following:

Example II

	Parts
Kentucky ball clay	15
Ground flint	15.5
Borax	19.5

Bonds according to both of these examples are soft at in the neighborhood of 1000° C.

Still considering preferred examples of the best manner of carrying the invention into practice, we may take four parts by weight of diamond bort of 100 mesh grit size and one part by weight of any of the above ceramic mixtures. We add thereto 4% of the whole of a 4% solution of "Glutoline" as a temporary binder, to plasticize the mass and to give it sufficient "green" strength.

Placing this mixture aside, we make an exactly similar mixture of bond and granular material which in the preferred form of the invention is vitreous silica (SiO_2), preferably of the same grit size as that of the diamonds, in the illustrative example 100 grit size. The proportion by volume of bond to silica should be the same as the proportion by volume of bond to diamonds. The amount of this second non-diamond containing mixture is calculated to have a volume, when compressed, that of the disk **22**, and likewise the volume of the diamond containing material is calculated to have the volume, when pressed, of the annulus **21**. The volume of these parts may be readily calculated geometrically and the total weight for a given volume will be readily calculated by those skilled in this art.

Referring now to Figure 1, we provide a mold comprising a mold ring, not shown, a bottom plate **25**, a top plate **26**, and a central plug **27**. We place in this mold a measured quantity of non-diamond containing mixture, as described above, and press in accordance with well-known practice. We then strip the mold from the mold ring and there exists between mold plates **25** and **26** a "green" pressed disk **22***a* of non-diamond containing material. Referring now to Figure 2, we next press the core **27** downwardly until it absolutely clears the top plate **26**. This permits the top plate **26** to be removed without injuring the pressed product **22***a* in any manner whatsoever as it can be slid off. After a pressing operation involving many thousand pounds to the square inch, both the top and the bottom plates stick to the pressed material thereof and have to be removed by relative movement in the nature of a shear in order not to destroy the pressed article. It is desired to loosen both top and bottom plates from the pressed article **22***a* and at the same time we desire not to remove the plug **27** at any time entirely from the central hole of the pressed product **22***a*, as otherwise there might be a breakdown of the grain and bond at the central hole. Therefore, we press the plug **27** downwardly to the position as shown in Figure 2 and no further.

Figure 3 shows the parts after the top plate **26** has been removed as described. The bottom plate **25** cannot so readily be removed from the pressed disk **22***a* with the plug **27** in this position, as the disk and the mold plate stick together. Referring now to Figure 4, we invert the parts shown in Figure 3 and provide a new bottom plate **31** of somewhat larger size but with a central hole the same as that of the plates **25** and **26**. We now locate this new bottom plate **31** in position, as shown in Figure 4, and by means of a pressing operation we press the plug **27** downwardly until the parts occupy the position shown in Figure 5. All these plug pressing operations may be readily performed in any hydraulic or mechanical press in a manner well known in the art, using an undersized plug as a pusher. Plate **25** is now removed by knocking it sideways as the plug **27** is clear of it. The parts are then in the condition shown in Figure 6, in which an oversized bottom plate **31** supports a pressed "green" wheel mixture or disk **22***a* comprising silica grain and ceramic bond, there being a central plug **27** of a length equal to the combined thickness of plate **31** and disk **22***a* which has never been removed from the central hole in the disk **22***a* although it has been pushed back and forth therein.

By reason of the procedure indicated, the disk **22***a* is handled with minimum danger of breaking off any portion thereof. Referring now to Figure 8, we provide second molding and pressing apparatus including an upper press plunger **35**, a lower press plunger **36** and a mold ring **37** of special characteristics, to be hereinafter described. Referring now to Figure 7, we now place the bottom plate **31** inside the mold ring **37**. Bottom plate **31** fits in the mold ring **37** with a sliding fit, preferably a reasonably tight fit. As shown in Figure 7, the disk **22***a* is still in position on the bottom plate **31**. The best manner of introducing the disk **31** into the ring **37** is to lower the plunger **36** until the plate **31** can be moved into position, clearing all obstructions, carefully centering it and then moving upwardly the plunger **36**. The press which may be used in practicing this invention is not found illustrated in detail as hydraulic presses are well known, and we utilize a hydraulic press having low and high pressure in order that the low pressure may be used when it is desired to bring parts into position and the high pressure may be used when actually pressing the mixtures. Low pressure is used in elevating the plunger **36** to introduce the bottom plate **31**.

We now take the measured quantity of diamond abrasive and bond prepared as above described and tamp it into the space between the mold ring **37** and the disk **22***a*, this diamond abrasive ceramic bonded material being indicated at **21***a* in Figure 7. We then place in position a top mold plate **41** which is shown in Figure 8. This plate may have a bayonet slot **42** for ready handling thereof. We now bring the plunger **35** downwardly with low pressure and the apparatus is ready for the second molding operation.

Still referring to Figure 8, the mold ring **37** is preferably made of cast steel and has an annular chamber **43** opening into an inner peripheral slot **44** extending all the way around the mold ring. The mold ring is an integral piece of great strength. Excepting for the slot

44, chamber 43 has only two entrances, viz. an opening 45 in the form of a tapped hole connected to a steel pipe 46 of great strength with a small bore. The other opening is another tapped hole 47 closed by screw plug 48. The mold ring 37 has an integral radial flange 50 in which is located a depression 51 to receive the pipe 46. A series of massive rods 52 are located around the periphery and extend through the flange 50 and are secured thereto and to a reinforcing ring 53 by means of nuts 54 fitting on threaded portions 55 of the rods 52. These rods 52 extend downwardly from a portion of the hydraulic press mechanism, not shown, and are suitably anchored thereto. The construction shown constitutes a mold ring 37 of great strength able to resist all ordinary forces in either vertical direction and having an annular chamber 43 able to hold enormous pressures.

In the chamber 43 and extending through the annular slot 44 is an annular rubber ring 60 of uniform cross section around the circle and of T shape in cross section, as shown. The corners of the junction between the chamber 43 and the slot 44 are rounded, as shown, and so also is the rubber at that point. Rubber is a deformable but not compressible substance and when subjected to comparatively large pressures flows practically like a liquid. Simultaneously we introduce high pressure through the pipe 46 and against the press plungers 35 and 36. This may be done by operating three high pressure valves from a single lever. The upper and lower press plungers 35 and 36 are provided in order that the enormous pressures which are preferably used to compact the material may not split the mold ring 37 open. We prefer to use pressures of the order of 6000 lbs. to the square inch. Difference in thrust of the plungers 35 and 36 owing to the weight thereof is readily taken care of by the supporting structure for the mold ring. When this pressure is applied in the manner indicated, the mixture 21*a* is compacted to the condition shown at 21*b* Figure 8 and all parts of this mixture as well as of the disk 22*a* are subjected to the pressure chosen. It will be seen that even the plug 48 which seals the opening 47 is backed up by the upper plunger 35.

After the full pressure has been turned on for a few moments, it is released in all three places and thereupon the rubber ring 60 expands to the position shown in Figure 9. The mixture 21*a*, however, is now compacted to a pressed peripheral annulus 21*b*. Both plungers 35 and 36 are then moved away from the ring 37 and a stripping member 65 of slightly less diameter than the bottom plate 31 is now placed in position and the lower plunger 36 is moved upwardly with the low pressure, which strips the plates 31, 41, plug 27 and pressed article comprising disk 22*a* and pressed annulus 21*b* from the ring 37. Upper plate 41 may now be readily removed by tapping it sideways. Then plug 27 may be removed by a downward pressing operation and the pressed article may be readily removed from the plate 31. The pressed article is then fired, as disclosed in our copending application, in an electrical furnace, first in an oxidizing atmosphere at a low temperature until the temporary binder has been burned out, thereafter at a temperature in the neighborhood of 1000° C. in a non-oxidizing atmosphere.

In the shrinkage following the application of the maximum heat, the vitreous silica, having a coefficient of expansion fairly close to that of diamonds, contracts at a rate close to that of the diamond abrasive. The ratio by volume of silica to bond is the same as that of diamonds to bond, and the bond in the inner portion is the same as that in the outer portion and, therefore, no shrinkage cracks appear and the article is an integral one-piece structure so far as its physical characteristics are concerned and has no strains therein, one physical characteristic alone excepted, and that is the abrasive properties of the annular band 21.

It will be seen that according to the construction shown, the pipe 46 does not move during use of the apparatus. A rigid pipe connection to the mold ring 37 is made possible by the use of two press plungers, viz. the upper press plunger 35 and the lower press plunger 36. By using a stationary mold ring, leakage of high pressure fluid is avoided. The chamber 43 may be and preferably is filled with oil at all times, and by reason of the provision of the hole 47 and plug 48 it is possible to remove all air from the chamber 43. Notwithstanding these advantageous features, it is a relatively simple operation to remove the mold ring 37 and substitute another one of a different size.

The fluid pressure that enters the chamber 43 is preferably equal to or even slightly greater than the pressure which was used to compact the disk 22*a*. This will insure a given grade hardness of the entire product and the volume percentage of abrasive, bond and pores or granular material, bond and pores will be very nearly constant throughout the mass. Under these conditions of a final pressing operation involving a given pressure which is transmitted to the entire machine, a homogeneous product without strains results.

So far as certain features of the invention are concerned, the apparatus may be used for molding diamond abrasive in the form of an annulus or ring upon any central disk which will withstand the vitrifying temperature in a ceramic kiln. Certain advantages of the invention may be achieved replacing the disk 22*a* with a prefired abrasive disk. Furthermore, the apparatus may be used to press mixtures including bonds other than ceramic bond.

It will thus be seen that there has been provided by this invention, a method and an article 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.

We claim:

1. Method of making a diamond abrasive wheel comprising preforming a central disk of granular material and bond, introducing around said disk a mixture of abrasive material and bond, and pressing said mixture radially by pressure derived from radial forces against the disk, then maturing both parts in a single maturing operation.

2. Method of making an abrasive wheel including an abrasive portion having diamond abrasive grains which comprises forming a mixture of diamonds and bond, forming another mixture of granular material and bonds using the same vol-

ume proportion of bond per total solids as in the first mixture, first pressing the latter mixture to form a disk, then placing the mixture of diamonds and bond around said disk, pressing the latter material radially by pressure derived from radial forces, and maturing the entire abrasive wheel in a single maturing operation.

3. Method of making a vitrified diamond abrasive wheel which comprises forming a mixture of diamonds with ceramic bond, forming another mixture of granular material with ceramic bond, pressing said latter mixture into the form of a disk, placing the diamond mixture outside of said disk in the form of an annulus, pressing the annulus upon the disk radially by pressure derived from radial forces, and firing at a temperature to vitrify the entire mass into a monolithic wheel.

4. The method of making an abrasive wheel comprising the steps of providing a central supporting body, placing a mixture of abrasive grains and bond around the periphery thereof, compressing said mixture radially by pressure derived from radial forces on said support and thereafter maturing the bond.

5. A grinding wheel comprising a central portion of ceramic bond and silica grain and an outer annular portion of ceramic bond and diamonds.

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