Aug. 10, 1943. L. H. MILLIGAN ET AL 2,326,381

APPARATUS FOR THE MANUFACTURE OF GRINDING WHEELS

Original Filed Nov. 19, 1936

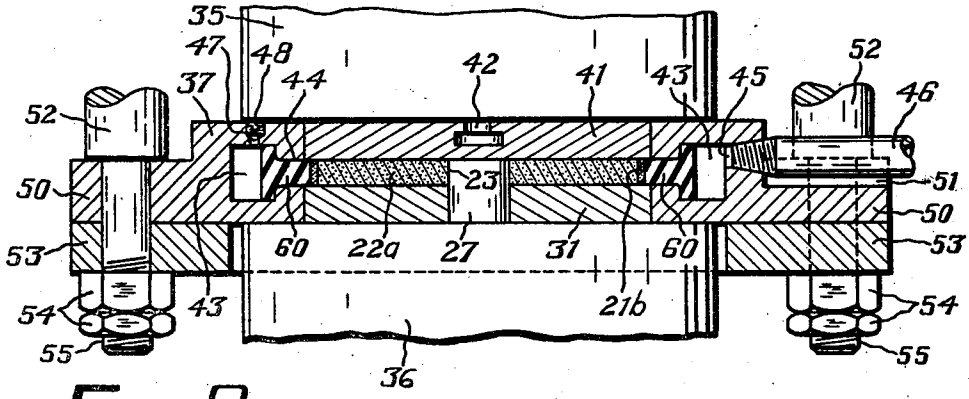


FIG. 8

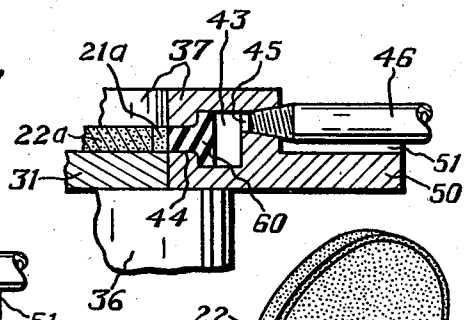


FIG. 7

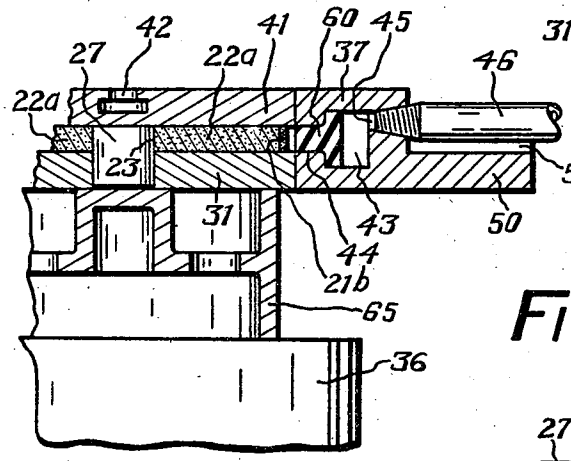


FIG. 9

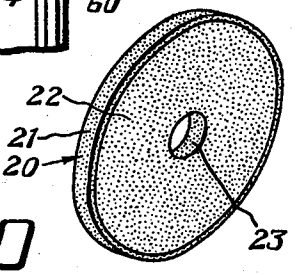


FIG. 10

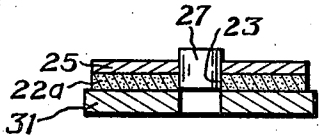


FIG. 4

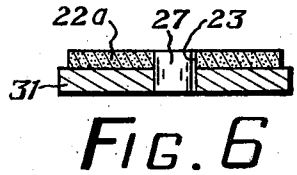


FIG. 6

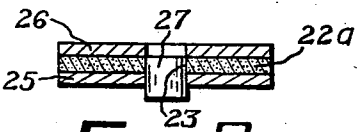


FIG. 2

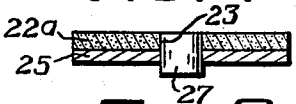


FIG. 3

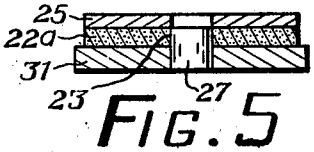


FIG. 5

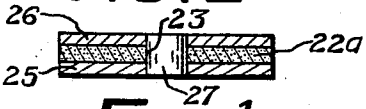


FIG. 1

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APPARATUS FOR THE MANUFACTURE OF GRINDING WHEELS

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Original application November 19, 1936, Serial No. 111,720. Divided and this application August 2, 1940, Serial No. 349,824

6 Claims. (Cl. 18—34)

The invention relates to apparatus for the manufacture of grinding wheels, and with regard to its more specific features to the manufacture of diamond abrasive wheels bonded with vitrified ceramic bond. This application is a division from our copending application Serial No. 111,720 filed November 19, 1936 which has become Patent 2,281,525.

One object of the invention is to provide a vitrified diamond grinding wheel of relatively large diameter at a reasonable cost. Another object of the invention is to provide an apparatus specifically adapted for the manufacture of a ceramic bonded wheel comprising an outer annulus of diamond abrasive material ceramically bonded and an inner disk or core of ceramically bonded granular material.

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;

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 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; and

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

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

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 made 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, equal to 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 ring from the mold 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 or platen **35**, a lower press plunger or platen **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 dydraulic 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 minutes, 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**. The 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 electric 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 liquid 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 an apparatus 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, 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. Mold apparatus for making a grinding wheel comprising an annular mold ring having an annular chamber therein connected with a source of fluid pressure, said ring having an internal cylindrical face and telescopically receiving therein upper and lower pressure plates and having a slot extending about said cylindrical face and communicating with said chamber and with the space between said two pressure plates,

means for exerting pressure to force one of said pressure plates in a direction toward the other and thereby compress in an axial direction grinding wheel material received in said above-mentioned space, a deformable member in said slot and forming a peripheral boundary for said space and operating under the action of said fluid pressure to compress said grinding wheel material inwardly in the direction of the radii to the axis of said cylindrical face.

2. Mold apparatus as claimed in claim 1, comprising means operable, during application of fluid pressure in said chamber to said deformable member, to back up the upper and lower portions of said mold ring that are respectively above and below said annular slot, thereby to avoid over-straining of the material of the mold ring under the effect of said fluid pressure.

3. Mold apparatus as claimed in claim 1, in which the said means for effecting compression of said grinding wheel material in an axial direction comprises means forming a backing for one of said plates and for that end of said mold ring adjacent said one plate and movable pressure-applying means operating upon the other of said plates and engageable, to limit the extent of axial compression of said material and to back up the other end of said mold ring against the action of fluid pressure in said annular chamber upon the parts of said mold ring to either side of said slot, with the mold ring at that end thereof adjacent said other plate.

4. Mold apparatus for making a grinding wheel comprising an annular mold ring having an annular chamber therein connected with a source of fluid pressure, said ring having an internal cylindrical face and telescopically receiving therein upper and lower pressure plates and having a slot extending about said cylindrical face and communicating with said chamber and with the space between said two pressure plates, means for exerting pressure to force one of said pressure plates in a direction toward the other and thereby compress in an axial direction grinding wheel material received in said above-mentioned space, said slot being of lesser axial dimension than the axial dimension of said annular chamber and connecting with the latter intermediate of its upper and lower axial extremes, and a deformable member in said slot forming a variable peripheral boundary for said space and having internally of said annular chamber upper and lower extensions to rest against the upper and lower portions of the internal wall of said chamber that is intersected by said slot, whereby, upon the application of fluid pressure in said chamber said deformable member is pressed radially inwardly against said grinding wheel material and its upper and lower extensions are compressed against said upper and lower wall portions of said chamber.

5. Molding apparatus for grinding wheel construction comprising means forming a space for receiving grinding wheel material, the peripheral boundary of said space comprising a ring-like member of deformable material, said ring-like member being of substantial radial dimension, means for exerting pressure thereon to cause it to compress said grinding wheel material substantially uniformly throughout its periphery and inwardly in the general direction of the radii of said ring-like member, and two axially spaced elements, each to one side of said ring-like member, to guide said deformable member radially inwardly and against displacement axially.

6. Mold apparatus for grinding wheel construction comprising an annular mold element having a top and bottom to form a space for receiving grinding wheel material, said annular mold element having therein an annular chamber communicating with said space by a continuous peripheral slot that is of lesser axial dimension than that of said chamber, a deformable means seated in said slot to close it off and having a peripheral portion exposed to said chamber that is of greater axial dimension than that portion thereof that is seated in said slot, and means for applying fluid pressure to said chamber to force said deformable member radially inwardly against, and to compress, said grinding wheel material.

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