Nov. 27, 1934. B. SANFORD 1,981,970

ABRASIVE WHEEL AND A METHOD OF MAKING THE SAME

Filed May 13, 1932

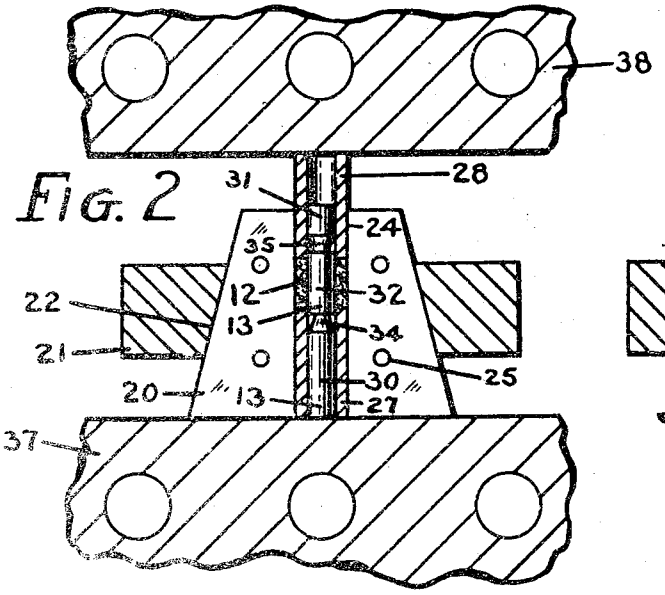


FIG. 2

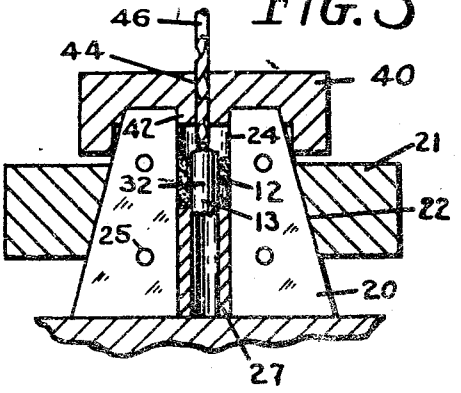


FIG. 3

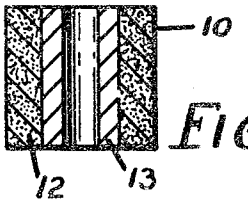


FIG. 1

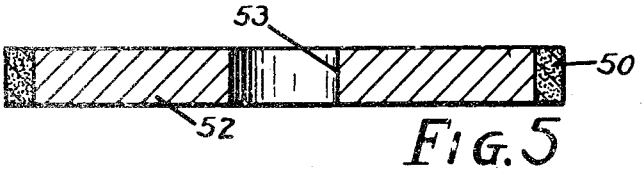


FIG. 5

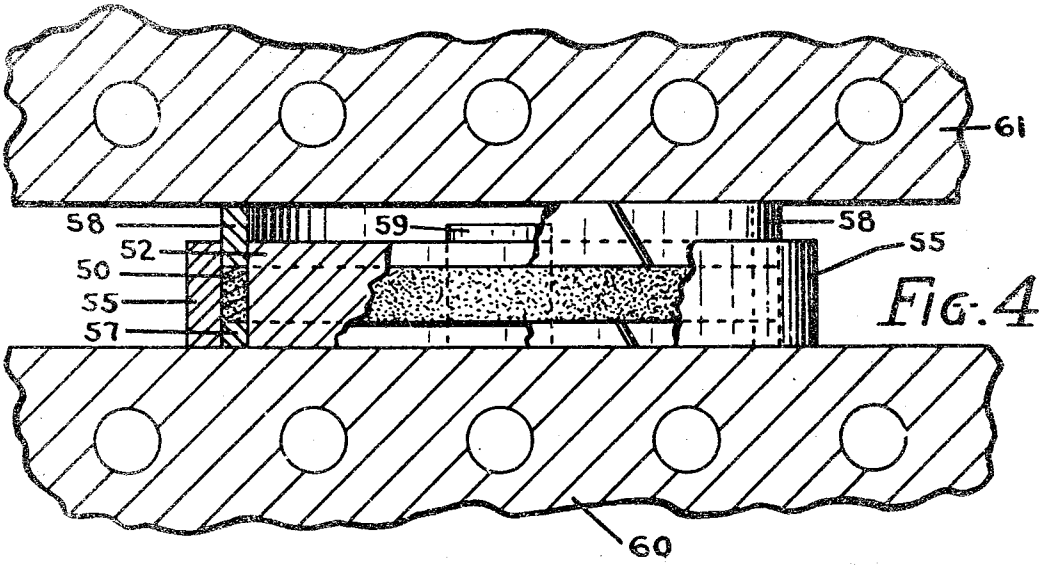


FIG. 4

WITNESS
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ABRASIVE WHEEL AND A METHOD OF MAKING THE SAME

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8 Claims. (Cl. 51—278)

This invention relates to grinding wheels and more particularly to a grinding wheel composed of bonded diamond granules and to a method of making the same.

In the manufacture of grinding wheels which contain diamond material for the abrasive substance, the common method of making a wheel is that of forming a body of the required size and shape from a soft ductile metal, such as soft iron or copper, and then incoporating very fine particles of diamond dust into the surface portions thereof. The dust is sprinkled on the respective surfaces of the metal body and is embedded therein under heavy pressure, as by means of heavy rollers. The surface is then inspected, after which further diamond material is sprinkled on the various surfaces particularly in vacant places, and the mass is again rolled. This procedure is repeated several times before a uniform and satisfactory distribution of the diamond material can be obtained. This method has the serious disadvantage of producing a weak structure consisting of crushed diamond particles and results in an abrasive surface in which the fine particles of diamond material form a superficial layer thereon with the abrasive particles arranged wholly in the top surface areas of the metal and being mechanically held therein, hence the wheel does not comprise a dense, compact integrally bonded abrasive structure. This prior type of abrasive surface also wears away rapidly and is uneconomical and of low efficiency, owing to the early loss of the diamond material by premature disruption from the metal to form a smooth surface before the abrasive particles may be economically and efficiently employed to a sufficient extent in the course of a normal abrading process. In such cases, the fine diamond particles, although held together by a material which is soft and wears away to the proper extent required to maintain an abrading surface, are not integrally bonded together in a manner which will serve to hold the abrasive material in place until their period of efficiency is past.

It is the primary object of this invention to overcome such difficulties and provide an abrasive article of bonded diamond grains which has improved grinding characteristics and a dense, integral structure throughout its abrasive zone, and in which the abrasive material does not appear solely upon the outer surface portions thereof but is interspersed uniformly throughout the entire mass of the body.

Another object of this invention is to provide an abrasive article which has an outer body of compressed abrasive material moulded integrally with a hollow central mounting support of a fragile and deformable character.

A still further object is to provide a simple and economical method of making such a wheel and of providing a dense and strong abrasive body of bonded diamond grains which may be formed and matured in situ integrally with the final mounting support therefor which serves for mounting it on the wheel spindle.

During the manufacture of these wheels it has often been found difficult to obtain a satisfactory bond between the grain surfaces and the bonding material arising from the fact that since the diamond has well defined cleavage planes along which fracture occurs, the bonding surfaces of the grains are often extraordinarily smooth and glass-like, and probably greasy, which prevents the bond from readily adhering thereto.

It is therefore, a still further object of this invention to provide a method of treating the bonding surfaces of the abrasive grains which serves to improve the bonding properties of the abrasive and tends to secure a more integral union between the different granules and the bonding material.

With these and other objects in view, as will be apparent from the following disclosure, the invention resides in the composition of matter and the process steps as set forth in the specification and covered by the claims appended hereto.

Referring to the drawing:

Figure 1 is a cross-sectional view, on an enlarged scale, of a small grinding wheel made in accordance with my invention;

Figure 2 is a cross-sectional view taken vertically through the mould and its associated parts illustrating the preferred method of moulding a grinding wheel of small size;

Figure 3 is a vertical sectional view through the mould and the drilling fixture showing the method of forming the mounting hole through the solid core of a small wheel;

Figure 4 is a vertical view, partly in section, through the mould and its associated parts showing the preferred method of moulding a grinding wheel of large diameter; and

Figure 5 is a cross-sectional view of a large grinding wheel made in accordance with the method shown in Figure 4.

In accordance with one phase of this invention, it is proposed to make an abrasive article which comprises an annular abrading body of granular abrasive material, such as diamond

grains, crystalline alumina or silicon carbide, united into an integral structure by a heat-settable type of bonding material. Such an abrasive wheel may comprise a hollow mounting support or core for the abrasive annulus of a yieldable and deformable character which during the initial and formative stages of the wheel manufacture is rendered sufficiently stiff and rigid to assist in the supporting of the formed mass of abrasive material while it is being shaped and moulded on the core. To this end, the core may be formed initially as a solid body, such as a solid rod or wire, the center of which, after the moulding step, may be removed by a subsequent boring operation so as to produce a hollow thin walled spindle mount integrally secured within and supporting the abrasive annulus. If desired, however, the core may comprise a hollow annular body into which a central stiffening or reenforcing member may be temporarily incorporated to give additional strength and rigidity to the support during the wheel forming and moulding operation. The core may then be centrally positioned within a sectional mould having a cylindrically shaped moulding cavity into which is subsequently introduced the abrasive moulding mixture. A predetermined amount of the mixture is placed in the cavity surrounding the core and the mass is then forced together and moulded, under the combined action of heat and high pressure, as by placing the mould and its contents between the heating platens of a hydraulic press, to form a compact and compressed mass of a definite structure "in situ" about and integrally united with the core. The article thus formed may then be subjected to a suitable bond hardening operation, which is carried out in accordance with methods well known in the art, and ordinarily involves heating the article at a moderate temperature for a sufficient length of time to further mature and finish set the bonding material. Since the abrasive mixture has been moulded and formed "in situ" about the mounting support, it will be found that the abrasive annulus is integrally united with the support and firmly cemented thereon due to the high moulding pressure and the tenacious bonding property of the matured bond.

In making the abrasive annulus, the bond for the granular abrasive material may comprise a bonding material of the heat-settable type, such as shellac, rubber or a reactive resinoid material of the type which becomes plastic and polymerizes under heat to form a matured, hard, insoluble, infusible product. It is preferred to employ for the bond, a resinoid material, such as a fusible potentially reactive phenolic resin of the type commonly known in the art under the trademark "bakelite." In practice, the resinoid may be employed either in the powdered state or in a fluid condition. When used in this latter form, the resinoid is ordinarily that known as a "liquid A" resin, by which term is meant the oily liquid obtained as the initial condensation product formed by the reaction of phenol and formaldehyde or by that of any of their homologues which under further heat treatment acquires a sticky resinous gummy consistency and which is sufficiently fluid to mix readily with granular material so as to coat the surface of the grains.

The diamond grains and the resinoid bond are then mixed together in suitable proportions so as to form an abrasive body of a desired structure. A finely divided filling material, such as ground flint or quartz sand, may also be incorporated with the resinoid and abrasive materials during the mixing operation as an extra ingredient when the diamond grains in coarse grit sizes, namely, those coarser than #100F, are employed. This filler tends to strengthen the finally matured bond besides serving to increase the consistency of the raw uncured bond to prevent it from flowing out of the mould when the mixture is pressed while in a heated condition.

Since the diamond has well defined cleavage planes along which fracture occurs, the bonding surfaces of the crushed grains are extraordinarily glassy so that it is often found difficult to cause the bond to adhere satisfactorily thereto. Therefore, it is desirable that the diamonds, after being crushed and graded to obtain the desired grit size, be treated either by washing, etching, oxidation or other various operations which produce satisfactory results to adhesively prepare the bonding surfaces of the grains without deleteriously affecting them. For this purpose, a cleaning process is preferably employed, in which case the grains are treated with a solution of chromic acid prior to being mixed with the bond. While this operation of grain treatment is considered to involve that of cleaning the bonding surfaces, the claims are to be interpreted as covering an operation involving pitting or etching the diamond surface.

As a specific example of one composition which will be satisfactory for the purpose of making a grinding wheel of bonded diamond grains in accordance with this invention, I may use diamond grains of a relatively coarse grit size, such as #30 grit, i. e., those which just pass through a screen having 30 meshes to the linear inch, and in which I may employ the ingredients in the following proportions:

	Per cent by weight
Diamond grains	50
Resinoid bond	25
Filler (ground quartz)	25
	100

This composition comprises a resinoid bond in a powdered state, such as a phenolic resin known under the trademark of "bakelite," and a finely divided inert filling material, such as quartz flour. It is desirable that the filler be preferably one which is pulverized to a size which passes through a screen of 200 meshes to the linear inch. The diamond grains may be used in a variety of sizes of grains or the particles may be uniform in size. as desired. For general purposes, however, the abrasive material employed may comprise diamond grains in grit sizes of from #24 to #320 mesh.

Reference now being had to the drawing, there is illustrated in Figure 1, in cross-sectional view, a small size abrasive wheel 10 of a composition such as described, comprising an annular abrading body 12 of resinoid bonded diamond grains and a central mounting support or core 13 which is most commonly composed of a soft ductile metal, such as brass or soft iron, although hard rubber or a matured resinoid material, such as a "bakelite" resin may be used. This core may either comprise a solid cylindrical body, such as a rod or wire, the center of which is removed after the moulding step as by a boring operation, to produce a hollow thin walled support for the abrasive annulus or it may consist of a hollow

sleeve or tube, the walls of which are rendered rigid, during the moulding process, by a stiffening plug temporarily incorporated therein.

In the manufacture of these small sized grinding wheels, namely, those composed of diamond grains of fine grit sizes and in which the diameter is one inch or less, the abrading body 12 is formed in situ on and integrally united with the solid core 13, as indicated in Figure 2 of the drawing. In practice, it is found desirable, in the case of such small wheels, to employ a split or sectional type of mould, since with a solid mould the sharp diamond grains, when subjected to the high moulding pressure necessary to compact the mass, "bite" into and become deeply and firmly embedded into the moulding surfaces so as to render it extremely difficult to remove the pressed wheel from the mould without causing damage to either member. For similar reasons, the proposed construction also dispenses with the use of an arbor during the wheel moulding operation, when diamond material is employed, on account of the grains becoming embedded in the surface thereof and thereby making it impossible to remove the arbor from the moulded body.

As a simple form of apparatus capable of carrying out the moulding operation, there is shown in Figure 2 of the drawing a device comprising a mould block 20, a pair of which constitutes a mould assembly of frusto-conical shape, and a circular mould band 21 having a bore 22 the sides of which are shaped to conform to and fit against the tapered exterior surface of the blocks 20. The mating faces of the blocks 20 are each provided with a pair of plane faces between which there is formed a semi-cylindrical recess of suitable dimensions, so that when the blocks are assembled, a cylindrical bore 24 will be formed whose axis is coincident with that of the mould blocks, and provides a mould cavity of prescribed dimensions for moulding the wheel mixture therein. The mating faces of one of the mould blocks 20 are also provided with dowel holes 25 which are adapted to receive suitable dowel pins carried by the opposed mould block so as to properly align the blocks with respect to each other when juxtaposed thereto.

In order to carry out the moulding step of the process, the mould is provided with a removable bottom member 27 and a removable and slidable pressure member 28, as shown in Figure 2, each of which comprises a hollow cylindrically shaped sleeve adapted to fit and slide within the bore 24 and on the wheel core 13, which is centrally located with the mould cavity preliminarily to the introduction of the moulding mixture therein, whereby the member 28 during the moulding process may follow down with the moulding material and press it into a compact mass about and on the core 13. The core 13 may be of substantially the same length as the bore 24, and has formed thereon a series of spaced hub portions 30, 31 and 32, respectively. The hubs 30 and 31 are formed at the respective ends of the core 13 with the hub 32 centrally disposed therebetween and spaced therefrom by means of the reduced portions 34 and 35 which are of frustro-conical shape and have their small ends adjacent to and joining the end faces of the hub 32. In this manner, the hubs 30 and 31 serve to correctly align and guide the members 27 and 28, respectively, with respect to the bore 23 during the moulding operations. It is desirable that the length of the hub 32 be slightly longer than the final width of the moulded wheel, after pressing, whereby the ends of the hub may protrude outwardly for a short distance beyond the end faces of the moulded wheel in order that one or both of the hubs 30 and 31 respectively, may be readily broken off at the respective portions 34 and 35 without injury to the moulded wheel and prior to boring a hole through the hub 32 for mounting the finished wheel on a supporting spindle.

As an illustration of one particular method of carrying out the pressing operation, the mould parts are first assembled with the solid core 13 in place and centrally located within the bore 24, and held in axial alignment therewith by means of the hub 30 which is located within the hollow member 27 positioned in the bottom portion of the bore. The abrasive mixture consisting of diamond grains and powdered resinoid in the above proportions is then placed within the mould cavity formed about the central hub 32. The pressure member 28, which is arranged to slide on the hub 31 within the bore 24, is then placed with the inner end face in contact with the top surface of the moulding mixture. The mould containing this mixture is placed between a pair of heating plates 37 and 38 respectively, such as the compressing platens of a "hot press," whereby the mass may be pressed in a heated condition. In a press of this type, the compressing platens are relatively movable by hydraulic pressure and are provided with suitable channels through which steam and water may be alternately run to expedite and complete the moulding process. Ordinarily, the mass is compacted under high pressure which is sufficient to unite the ingredients without preventing the free escape of the volatile gases, but in some cases it is desirable that the abrasive mixture be initially held confined within the mould at a low pressure to prevent any swelling tendency of the bond and a consequent disarrangement of the uniformly distributed abrasive grains and bond as the gases escape freely therefrom. The mixture may now be pressed while in the heated state to form the shaped abrading body by moving the compressing plates or platens together under any suitable hydraulic pressure until the pressure member 28 contacting with the abrasive material has been moved to produce a desired and definite structure. In general, the abrasive body 12 ordinarily comprises a bonded structure of high density and low pore volume and in which a low abrasive packing is employed, preferably of from 20% to 40% by volume of diamond grains, since the diamond material per se is very expensive, so that the amount of material which may be economically used commercially is thereby limited, and besides the maximum bonding power of the bond with the diamond grains is obtained when less diamond material is used. If desired, the diamond content may, however, constitute 60% by volume of the body to obtain a faster cutting wheel.

The mould and its contents are then cooled, as by circulating cold water through the channels in the press platens, while the mass is under the compacting pressure, after which the pressure, is released and the mould removed from the press. The mould parts may then be disassembled and the pressed article taken out of the mould cavity. One or both of the hubs 30 and 31 of the core 13 are now broken off from the middle core portion or hub 32, on which is moulded the wheel mixture, at the respective relieved portions 34 and 35 thereby leaving the

fractured ends of the hub 32 protruding slightly beyond the end faces of the moulded wheel. The mould may now be reassembled for a boring operation, as in the manner such as illustrated in Figure 3, and with the moulded wheel mounted inside of the bore 24 and on top of the mould member 27 with one of the ends of the hub 32 projecting down inside of the cylindrical bore of the sleeve member 27.

For this hole forming operation, I may employ any suitable form of boring or drilling apparatus, in which the drilling tool may be operated either by power or by hand, as is shown in Figure 3. This may comprise a cylindrical block 40 arranged to fit over the top portion of the mould 20 and having a hub 42 shaped to enter the open upper end of the mould bore 24 and align the block 40 axially therewith. The hub 42 is provided with a central aperature 44 which is accurately aligned with the axis of the hub 32 in the moulded wheel to enable a drilling tool 46 to be inserted therein, whereby the hub 32 may be drilled effectively so as to form a mounting hole for the moulded wheel. By having the wheel confined within the mould the drilling operation may be successfully accomplished without danger of injuring or breaking the abrasive body or its support. Furthermore, by using a boring jig to mechanically center the hole, the drilling operation may be effected in an accurate and precise manner. After the hub 32 has been drilled to form the hollow core 13, it may be removed from the mould and thereafter treated by a grinding operation which removes the hollow fragmentary end portions of the former hub 32 which slightly project outwardly from the sides of the molded wheel faces and as a result a wheel such as is shown in Figure 1 is obtained. The wheel is now finished but, if desired, it may be again heat treated, as by a baking operation, to further mature and set the resinoid bond. It is to be understood that such heat treatment may be accomplished in accordance with standard practice.

If the abrasive wheel to be made is of a large size, that is, one having a diameter of one inch and greater, a slightly modified construction and method of manufacture may be employed. Due to the prohibitive cost of manufacturing a solid wheel of large diameter with diamond material, the construction employed, as shown in Figure 5, comprises a composite body, the outer layer or rim 50 of which consists of a mixture of chips of diamond material bonded by means of a mouldable heat-settable material, such as rubber or a resinoid material, into a dense structure. The inner layer or core 52 consists of a preformed disc of rubber or resinoid material which strengthens and supports the facing layer and is provided with a central aperture 53 moulded therein which serves for mounting the wheel on a driving shaft.

As a specific form of apparatus which I have found to be suitable for moulding a large wheel, I may employ for the mould member a cylindrical band 55 having arranged therein a pair of ring-shaped pressure members 57 and 58, respectively which are preferably of a diameter to closely fit the interior of the band and are relatively slidable therein and with respect to each other whereby they may serve to compact the moulding mixture to the mould shape and to the desired extent. To avoid sticking of the rings 57 and 58, due to expansion when subjected to the moulding temperatures, the side of each ring is preferably cut or split, as shown in Fig. 4, in order to provide clearance sufficient to compensate for expansion and thus permit the body of the ring to closely fit and conform to the inner surface of the mould bond and yet be readily removed therefrom upon the completion of the moulding operation. The sides of the ring 58 are preferably made of sufficient height for it to project above the top of the band 55, when the ring is located in its normal moulding position within the band, in order that it may receive the required moulding pressure from the press to compact the moulding mixture.

In order to produce such a wheel, I first position the preformed core 52 inside of the band 55 and then center and align it axially therein by means of the ring 57 the inner sides of which surround and are in contact with the periphery of the core 52 and the outer sides in engagement with the inner walls of the band 55. A short arbor 59 is inserted through the mounting hole 53 to prevent the material forming the sides of the hole from flowing and producing an out-of-round condition while the mass is being hot moulded. The cavity above the ring 57 and defined by the respective sides of the band and the core is then filled with the proper amount of the resinoid and diamond abrasive materials in powdered form which have previously been mixed in the required proportions. The upper ring 58 is placed over the mass and pressure and heat is then applied thereto by means of a pair of heating plates 60 and 61 of a "hot press" to convert the resinoid of its final form and to compact the mass in situ about the core 52. After subjecting the mass to heat and pressure to form the body, it is then removed from the mould and the end portions of the resinoid core 52 which now project outwardly from the rim 50 are then ground down flush with the top of the rim, by any suitable grinding operation, to obtain the finished wheel as shown in Figure 5 of the drawing. If desired, the wheel may be subjected to an additional heat treating operation in order to further toughen the resinoid bond.

In accordance with my invention, it will be seen that I have provided a grinding wheel having an extremely hard quick cutting and wear resisting working face in which the abrading body of resinoid bonded diamond grains comprises a hard strong integral mass which firmly grips the supporting mount on which it is formed. A grinding wheel, made in accordance with this general method of procedure and embodying diamond grains may be employed for grinding the improved type of cutting tools having cutting facings of metal alloy compositions, such as those of the cemented tungsten carbide and commonly known under the trade-mark "Carboloy," applied to their working edges which, due to their resistance to abrasive wear and extreme hardness, have been found difficult to grind at a fast rate and in an economical and efficient manner with the ordinary type of grinding wheel. Furthermore, it is found that the edge faces of the improved wheel comprise a hard infusible wear resisting material which will not break off or chip easily when grinding right-angled corners, an operation which cannot be done satisfactorily with the standard grinding wheel.

While I have specifically illustrated and described the preferred embodiment of my invention, it is to be understood that the invention is not limited to the specific details as above set forth, but that the invention broadly applies to such other modifications as may be made without going beyond its scope and accordingly such

changes are considered as being embodied in the above specification and in the appended claims.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A diamond abrasive wheel comprising a preformed rigid central support having an inner surface adapted for mounting on an arbor and an annulus of bonded diamond granules integrally united with said support, the bond being of a heat settable material which has been both molded under pressure and matured in situ on the support, and the diamond granules adjacent to the inner face of the annulus being embedded in both the bond and the support, thereby aiding in holding the annulus integrally fixed on the support.

2. A diamond abrasive wheel comprising a thin walled annular core of deformable metal and an abrasive annulus of bonded diamond granules integrally united therewith, the bond being of a heat settable material which has been both molded under pressure and matured in situ on the core, and the diamond granules adjacent to the inner face of the annulus being embedded in both the bond and the metal core, thereby aiding in holding the annulus integrally fixed on the core.

3. A diamond abrasive wheel comprising a preformed rigid core having an inner surface adapted for mounting on an arbor and an annulus of bonded diamond granules surrounding and integrally united with said core, the bond comprising a resinoid material which has been both molded under pressure and matured under heat in situ on the core, said diamond granules being precleaned by a treatment which improves the adhesion of the resinoid bond to the surfaces of the crushed granules, and the diamond granules adjacent to the inner face of the annulus being embedded in both the bond and the core, thereby aiding in holding the annulus integrally fixed on the core.

4. An abrasive wheel comprising a central, preformed, rigid supporting core and an abrasive annulus integrally fixed thereon containing diamond grains, granular inert filling material and a resinoid bond integrally united with the rigid core, the resinoid being reacted and matured in situ with the core into a hard body under the combined action of heat and high pressure while located in the final position thereon, and said core being of sufficient strength and the desired physical characteristics as to withstand the high pressure during molding.

5. The method of making an abrasive article of bonded diamond grains comprising the steps of chemically treating the grains to prepare the bonding surfaces for adhesion to the bond without deleteriously affecting the grains, mixing the treated grains with a resinoid bond, molding the mixture under pressure and in situ on a central, preformed, rigid supporting core and maturing the resinoid bond by the action of heat to form a hard body integrally united to said core, and thereafter drilling the core to form a hollow supporting mount for the wheel.

6. The method of making an abrasive wheel having a moulded, heat-matured annular abrasive body and a hollow thin-walled central spindle mount therefor which is of such dimensions that it would be deformed under the pressure of moulding comprising the steps of moulding a mixture of abrasive grains and a heat-settable binder on a rigid supporting core to form an abrasive annulus, the inner peripheral surface of which is united integrally with the exterior surface of the core, and then forming a hollow thin-walled annular wheel mount of the core by subsequently removing from the central portion thereof the stiffening material contained therein.

7. The method of making an abrasive wheel having a moulded, heat-matured abrasive annulus and a hollow central spindle mount therefor which is of such dimensions that it would be deformed under the pressure of moulding comprising the steps of providing a rigid mould core, placing said core in a sectional mould having a shaped moulding cavity, shaping an abrasive annulus thereabout by surrounding the core with a mixture of abrasive grains and a heat-settable binder, pressing the mass to form a compact abrasive body integrally united with the core, and subsequently removing from the center portion thereof the body of material which maintains the core rigid and stiff during the moulding operation so as to form a hollow annular mount for the wheel having the desired thickness of walls.

8. The method of making a grinding wheel comprising the steps of providing a solid support, molding and maturing a mixture of diamond grains and a heat-settable bond under heat and pressure in situ on said support to form a hard, dense abrasive body integrally united therewith, and thereafter drilling the solid support to form a hollow supporting mount for the abrasive body.

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