ABRASIVE SURFACE AND METHOD OF PREPARING THE SAME

Filed June 7, 1938

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.
Abrasive Surface and Method of Preparing the Same

Patent No. 2,226,607

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This invention relates to abrasive surfaces, and in one of its aspects, to the supporting medium by which abrasive grains may be held in proper position for cutting or polishing operations. In another aspect the invention relates to a new arrangement of abrasive grains. The invention is believed to involve both new means, and a new process, for making an abrasive surface, as well as to the surface so made and the tool embodying the same.

In the description of the invention which follows, diamonds will be referred to for purposes of illustration as the cutting medium but, while the invention is at present believed to have its chief field of utility in connection with diamond-contoured abrasive surfaces, the intention is that the supporting medium and modes of application as hereinafter described and claimed may be useful in connection with abrasive grains of less hardness than diamonds.

Grinding tools having a diamond-containing abrasive surface of certain types are known and, subject to certain disadvantages pointed out below, have been used. In their use it has been found that, for effective cutting, the diamond-containing abrasive surface should preferably be moved at a high speed in relation to the work, a speed of between 5500 and 6000 superficial feet per minute being considered best practice. Accordingly it is customary to embody the diamond-containing abrasive surface upon the periphery of a rotating member such as a wheel, tube, shaft or spindle. The diamond-containing abrasive surface of the present invention may be applied to such a member, or in addition may be used with tools having a reciprocating motion. Where the general term "wheel" is hereinafter used it will be understood to include any of the foregoing means whereby the abrasive is brought in contact with the work, even though in some cases the motion may not be rotative.

As is well known, crystal diamonds are very brittle and under proper conditions may be crushed and will fracture into fragments of extremely small size. By the term "crystal" diamonds, we refer to all forms of diamonds including white, gray, yellow or brown diamonds, but exclude carbonado or black diamonds. Commercial crystal diamonds used for abrading or other technical purposes are called "bort." As the diamond particles are broken the breakage tends to occur along fracture planes which produce extremely sharp edges and corners. As the diamond is the hardest substance known its hard, sharp edges will under proper conditions cut every other known material beside itself, including tungsten carbide which is an extremely hard material used for the cutting edges of machine tools. Diamonds will also cut other diamonds, though at a slower rate and with greater attendant destruction of the cutting diamond.

In such operations the question has long been presented of the best manner of holding and supporting the cutting diamond. For reasons of economy and adaptability the "cutting diamond" ordinarily is not a single stone or fragment, but comprises a surface studded with tiny diamond fragments, and the problem to which the present invention is directed is the proper support of a large number of such fragments in a surface of any desired shape in such manner that the cutting edges of the diamond fragments will be properly presented to the work and yet will be supported in a manner sufficiently yieldable to prevent excessive chipping or fragmentation of the diamond fragments, and the supporting medium or matrix will have the characteristics of breaking down or pulverizing (uncovering fresh diamond fragments) at a rate fast enough to prevent glazing or smearing, but not so fast that substantial chunks or sections will break away with attendant wastage of unused diamond particles.

Prior to the present invention several methods have been employed for the cutting of hard substances such as diamonds or tungsten carbide. In cutting or polishing diamonds it has been the practice of jewelers and diamond workers for generations to rub one diamond upon another, until the diamond being worked upon has been worn down to the desired surface. This process is known as "bruting" and is subject to the disadvantage that there is constant danger that either the diamond used as the tool, or the diamond being worked on, may flake or chip resulting in large loss of value or usefulness. For this reason many jewelers and diamond workers prepare a suspension of fine diamond particles in oil, and rub the same upon the diamond being worked on by various mechanical instrumentalties. But the difficulty of this procedure is that the diamond-carrying oil tends to find its way by capillary attraction into the bearings of the machinery used to effect the rubbing, with attendant rapid destruction of the bearings requiring frequent and expensive replacement.

A further expedient employed for cutting or polishing of diamonds has been to charge the smooth surface of a cast iron wheel with fine diamond particles, and to use this surface as a
grinding or cutting medium. In order to charge the surface of a cast iron wheel with diamonds it is necessary to apply loose diamond dust and then roll it into the means of rollers made of a metal having equal or greater hardness than the surface to be charged. Not only is this process wasteful, because of the attendant loss of dust and the unnecessary charging of the surface of the rollers, but the diamond particles forced into the surface of the cast iron wheel tend to be damaged in the process. The pressure is applied to them in such a manner as to dull those edges which are afterwards to be relied upon as their cutting edges, and there is a tendency for the diamond fragments to become further fractured and broken down into still smaller pieces. For this reason the only diamond particles which can be charged to the surface of the cast iron wheel are those which are very small, because larger particles fracture under the pressure. In consequence, diamond-charged surfaces of this type necessarily have a very slow rate of cutting, because of the smallness of the diamond particles which can be made to adhere to such surface, and such wheels are therefore unsuited to the sharpening or cutting of tungsten carbide tools and other hard substances where, for practical commercial purposes, a relatively high rate of cutting is necessary for economical operation. Furthermore, the diamond-charged surface of a cast iron wheel is soon worn out because there is no substantial depth of diamond dust upon the surface and because the diamond fragments embedded in the surface are so rigidly held in the hard metal that they themselves tend to be worn away or further shattered by impact with the material being worked upon. Lastly, diamond-charged cast iron wheels have no breakdown of their own, and therefore cannot not clear themselves of waste-matter but become smeared or glazed therewith destroying their capacity to continue cutting where the waste-matter is a substance softer than diamond. Such wheels, accordingly, are of notoriously short life and at best are slow cutting and unsatisfactory. Efforts have heretofore been made to produce a diamond wheel of longer life and faster cutting power by embedding diamond particles of any desired size uniformly throughout a pressure-hardened layer of phenol-formaldehyde resin (which will be herein referred to by its common name "Bakelite") applied in substantial depth upon the surface of an appropriately shaped wheel. The mixture of diamond dust and powdered resin is applied to the surface of the wheel in a suitable mold and is secured thereon by the application of high temperature and high pressure. Such process is described in the Sanford Patent No. 1,981,970 granted November 27, 1934.

Diamond wheels such as those last described above have been found in practice to be notably "tender" especially when used for the cutting of very hard substances such as diamonds or tungsten carbide. In the hands of operators employed on a piece-work basis, where the tendency is to increase the pressure of application of the cutting tool upon the work in order to hasten the rate of cutting, it has been found that there is a tendency for the "Bakelite" resin which supports the diamond fragments to flake off in fairly large chunks or sections under the influence of heat and the impact upon the work. Such flaking not only results in loss of substantial diamond value in the flaked-out or torn-off portions, but results in the formation of a channel or trough in the abrasive surface with attendant destruction of the accuracy thereof especially when used for the cutting of precision tools. Flaking of this character is seen to be a serious factor when it is pointed out that, for adequate bonding and because of the necessary limitations of molding under pressure, a diamond-containing resin cannot practically be made of less thickness than 1/8 of an inch. Since diamond dust is a very expensive commodity, and the scoring or pulverizing of that portion of the surface which makes contact with the work soon destroys the usefulness of the whole wheel, it has been found that diamond wheels of the "Bakelite" resin construction are very costly to use because a substantial amount of the diamond value purchased cannot be employed for cutting purposes but is lost when the grooved wheel has to be thrown away.

Apart from the foregoing difficulties with the diamond-containing "Bakelite" resin wheel, is the problem of proper rate of breakdown. As the present invention is believed, in one aspect, to provide means for obtaining greatly improved breakdown characteristics, it will be desirable to point to the problem involved.

The hardness of an abrasive surface must bear a proper relation to the hardness of the material being worked upon. "Soft" metals such as brass or "sticky" metals such as aluminum have a pronounced tendency to smear or glaze upon the surface of the supporting medium in which the abrasive grains are embedded, and this supporting medium must be capable of a relatively rapid rate of disintegration or pulverization in order to "clear" the surface of adhering waste-metal so that the abrasive grains can continue to cut. On the other hand, very "hard" metals such as hard chilled steel or tungsten carbide have less smearing or glazing tendency but have a more destructive effect upon the abrasive grains, and for cutting such substances the supporting medium for the grains must be more resistant to disintegration or pulverization so as to resist tearing out of substantial sections of the surface. Some degree of rate of breakdown is necessary in all abrasive wheels, however. One of the difficulties with the "Bakelite" resin wheels above referred to is that no substantial adjustment can be made in the rate of breakdown of the supporting medium according to the nature of the work. "Bakelite" resin may be a desirable supporting medium for some classes of work, but it can only be used on the really hard substances, such as diamond or tungsten carbide, subject to the disadvantage that its supporting medium is not suited thereto because it has too high a rate of breakdown, resulting in a "tender" wheel of relatively short life.

The object of the present invention is to produce a diamond-containing abrasive surface in which the supporting medium for the abrasive grains consists of varnish or lacquer containing fibrous material whose physical characteristics may be selected in accordance with the desired rate of breakdown. One feature of the invention is that the diamond-supporting medium may be substantially shallower in depth than the "Bakelite" resin heretofore known, thus minimizing wastage of unusable diamond value when the wheel reaches the end of its useful life, while at the same time the tendency of the "Bakelite"
resin medium to flake or scale away is practically entirely eliminated. In consequence diamond wheels made in accordance with the present invention are much "tougher" than "Bakelite" wheels, have a longer life, may be made with a rate of breakdown suited to the hardness of the material to be cut, and may be made with a rate of breakdown well suited to the very hardest materials such as diamond, tungsten carbide and chilled steel.

Referring to the annexed drawing forming a part of this specification:

Figure 1 shows in cross-section a so-called straight grinding wheel.

Figure 2 shows in cross-section a so-called plain cup grinding wheel.

Figures 3 to 7, inclusive, are perspective views of a portion of the abrasive surface of a diamond wheel upon a much enlarged scale indicating the successive steps involved in the application thereof to a diamond-bearing abrasive surface embodying the present invention, the steps represented being as follows:

Figure 3—The bare corrugated surface to be treated.

Figure 4—the woven fabric 12 applied thereto.

Figure 5—the woven fabric 12 pressed down and secured to the surface with the aid of a suitable adhesive.

Figure 6—diamond dust applied loosely upon the upper surface of the woven fabric and incorporated therein by friction or otherwise.

Figure 7—the structure completed by application of the coating 14 whose nature is described below.

Figure 8 shows on an enlarged scale, another form of abrading surface of a grinding wheel made according to my invention as it would appear during use. It illustrates the spaces or pockets which appear as a result of the manufacturing process which serve for holding cooling medium or lubricant as well as providing clearance for broken-down material.

Figure 9 shows diagrammatically in cross-section the relation of the successive layers in one form of structure embodying this invention. In this case the abrasive material is applied upon a plane, and not a corrugated surface.

Figure 10 shows diagrammatically in cross-section the effect produced when the coating 14 herein described is used for the repair of a worn grinding wheel of any type.

Referring to the annexed drawing, wherein like reference characters designate like parts in the several figures—

A diamond wheel ordinarily comprises a support or core of metal, wood, "Bakelite" resin or other desired substance shaped in accordance with the requirements of the work. For convenience this supporting core will be herein referred to as the "wheel" and for convenience a metal wheel will be referred to as illustrative.

Upon a peripheral, annular or other circular surface 11 of the wheel 10, is built up the diamond-containing abrasive surface which, in one of its aspects embodies the present invention.

The surface 11 may be smooth metal—that is, all parts thereof may lie in an annular plane, or in the surface of a cylinder, cone or sphere. In one of its aspects this invention proposes that the surface 11 may be knurled, serrated, corrugated or marked with small grooves running radially or spirally or circumferentially as may be appropriate for the particular tool. For convenient exposition the surface is shown in Figure 3 as having small corrugations running at right angles to the direction of travel relative to the work.

Upon surface 11 is applied one or more layers of woven fibrous material 12, suitable adhesive being used to secure said material to said surface. The material 12 may consist of finely woven cotton or linen cloth, or it may consist of woven fabric made of asbestos fibre or of spun glass. While this material is herein referred to as fabric or as being woven, the intention is to include any form of sheet-like material embodying interlocked fibres so incorporated as to give the sheet a sufficient body to serve the designated purpose, whether the fibres are interlocked by weaving or in any other form of knitting, matting, felting or the like. The amount of adhesive employed should, of course, be sufficient to make a firm bond between the fibrous material and surface 11, but should not be enough to soak or saturate the material 12 so as to prevent the diamond-dust, subsequently to be applied, from penetrating within the interstices of the fibres. If there is too much moisture in the fibrous material when the diamond-dust is applied, the latter will be accumulated at the surface and prevented from penetrating within and among the fibres. The material 12 is secured to the surface 11 by means of a very thin coating or film 16 of waterproof varnish or other suitable adhesive material applied in such a manner that the liquid varnish or adhesive does not soak through or saturate the material 12 but, after material 12 has been secured in place, the same is substantially dry to all appearances on its upper surface. The material 12 is pressed down into intimate contact with the serratations or corrugations of the surface 11 so as to reproduce on its upper surface at least the major outlines of the conformation of the metal surface (as indicated in Figure 5).

After the material 12 has been securely affixed upon the surface 11, the diamond dust 13 of any desired mesh size is then sprinkled upon the dry upper surface of the material 12 and is mechanically worked in until the diamond particles have saturated the interstices between the fibres of the material 12. For this purpose diamond particles of uniform mesh size may be used, or mixtures of diamond particles of different mesh sizes, depending upon the character and nature of the work to be done. The diamond dust may all consist of the usual grades of crystal diamond, ranging in size from the larger fragments known as diamond sand, Klatersel and small cleavages down to the extraordinarily fine fragments which can only be separated in an oil bath, or other forms of diamond may be used of the type known as Brazilian carbonado or black diamond, either singly or in admixture in varying percentages with crystal diamond fragments, as set forth below.

After the diamond dust of fragments have been thoroughly incorporated in the fibrous material 12, there is then applied upon the surface of material 12 a coating 14 whose composition may be as follows:

In the liquid state—

<table>
<thead>
<tr>
<th>Parts by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varnish</td>
</tr>
<tr>
<td>Crystal diamond grains</td>
</tr>
<tr>
<td>Carbonado grains</td>
</tr>
</tbody>
</table>

Fiber filler

75
In the dry state the proportions are as follows:

<table>
<thead>
<tr>
<th>Varnish</th>
<th>Crystal diamond grains</th>
<th>Carbonado grains</th>
<th>Fiber filler</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts by weight</td>
<td>25</td>
<td>54</td>
<td>6</td>
</tr>
</tbody>
</table>

The first of these two formulae gives the relative proportions in parts by weight of the liquid compound or mixture. The second formula gives the relative proportions in parts by weight when the liquid compound or mixture is resolved into final hard condition by heat drying; i.e., it shows the relative proportions after the volatile element has been driven off by heat. The change in relative proportions is due to the fact that while in its dry state, the compound or mixture retains all of its original solid ingredients, it contains only the non-volatile portion of the original liquid varnish.

Varnishes or lacquers which we have found particularly applicable for use are glyptol resins, formaldehyde-urea, and esters of acrylic acid. Glyptol resins are advantageous and preferred because their air drying properties permit resoling of scored places on a wheel in the absence of adequate heat drying apparatus. Formaldehyde-urea is advantageous because this material is found to surround the diamond particles readily, adheres with great strength and resolves itself into a dense, compact body and is notable for absence of checking or cracking. Esters of acrylic acid are found to have advantageous properties which make their use particularly effective in certain types of diamond wheels for special grinding purposes.

Other types of varnishes or lacquers may, however, be employed in preparing the coating which meets the requirements outlined below.

The coating 14 comprises a suspension of diamond particles 13 together with fibrous material in a varnish or lacquer medium. The diamond particles used may be of the same or of differing mesh size, and may be either of crystal diamonds and the Brazilian carbonado or black diamond referred to below. Preferably the varnish or lacquer should be one which is capable of hardening at atmospheric pressure by the escape or oxidation of certain of its constituents, and not a varnish of the "Bakelite" type which hardens by chemical condensation under super-atmospheric pressure. The hardness of the varnish or lacquer when dry may be selected according to the results desired. Where the term "varnish" is hereinafter used it will be intended to refer to such a substance as is described above.

In one of its features or aspects this invention proposes the suspension in the above-mentioned coating mixture of a proportion of loose fibrous material. Such fibrous material may consist of vegetable fibre such as linen or cotton, or mineral fibre such as asbestos or short hair-like strands of spun glass. The proportions and character of this ingredient in the mixture will depend upon the characteristics of the grinding surface which it is desired to produce, and upon the desired rate of break-down of that surface. For example, when the coating 14 contains cotton or linen fibres, the resultant abrasive surface will have good efficiency on some metals but will lack cutting efficiency on others. The use of asbestos fibres in place of cotton or linen may decrease the cutting efficiency in the former case and increase it in the latter. The use of spun-glass fibre, in particular, appears to produce an abrasive of maximum cutting efficiency on the very hardest substances, such as diamond, tungsten carbide and chilled steel. Ordinarily if the coating 14 is to be placed upon material 12 consisting of woven asbestos fabric, the coating applied will contain asbestos fibre; and the same is true with respect to the other fibres mentioned. It is, however, within the contemplation of this invention to utilize fibres of different character in the coating from those comprising the woven material 12, where contrasting physical characteristics thereof would produce useful results.

In one of its aspects this invention proposes the use of Brazilian carbonado or black diamonds for use in the supporting medium hereinafore described. Such diamonds are wholly different in physical appearance from the crystal or brilliant diamond which is familiar to jewelers. The Brazilian carbonado or black diamond has no smooth surfaces, is without cleavage planes, is densely porous, and has not heretofore been employed for cutting purposes (certain uses in bricking). Under the microscope this stone resembles a cinder, clinker or volcanic pumice but with pores much smaller in size. These pores form a pitted surface and the thin partitions formed between the pits are extremely sharp and hard for cutting purposes. Such a stone appears to be exceedingly useful in the formation of an abrasive surface in accordance with the present invention, in part because it appears that the pits or pores furnish a strong point of anchorage for this type of diamond when it is embedded in the hardened supporting medium of the present invention. Carbonado diamonds are just as hard as the ordinary crystal diamonds, and are noticeably harder than any of the artificial abrasive materials, such as silicon carbide or boron-carbide, and have good cutting qualities. A mixture of 10% carboneado to 90% bort makes an effective abrasive mixture.

The coating 14 may be applied to the surface of the material 12 in any suitable manner, as by brushing or spraying. Sufficient is applied to impregnate the woven fabric and to form a slight coating thereon. After hot-air drying or baking, this coating becomes a hard solid film, thoroughly soaked among the fibres of the woven material 12 and the latter firmly secured upon the surface 11. The shrinkage of the varnish during the drying operation results in giving a slight prominence to the strands of the woven material 12, and the entire surface is slightly undulated by reason of the corrugations, if the abrasive is built up upon a corrugated surface.

When the coating 14 is dry and hardened, the surface is ready for use. The result is a diamond-bearing abrasive surface in which diamond fragments of any desired size may be incorporated. The character of such wheel may range from a coarse roughing wheel having diamond grains of a mesh as coarse as No. 16 down to a fine finishing wheel having diamonds of mesh finer for developing extremely high polishes. At the same time the supporting medium in which the diamond fragments are embedded may, if the fibrous material be strong (e.g. spun glass), have a rate of breakdown suited to hard substances, or if the fibrous material be of less tensile strength (e.g. cotton or asbestos) have a rate of breakdown suited to less-hard substances. In addition, asbestos fibres appear to resist the transmission of heat and to localize
the heat produced by friction so that the same can be dissipated by the water applied to the surface of the wheel while it is in use and, when using a spurn glass, it appears that the particles of glass pulverised from these strands during the breakdown of the surface furnish a useful addition to the abrasive elements brought to bear upon the work.

In another aspect the invention proposes the formation of pockets or voids in the hardened material in which the abrasive grains are suspended. We have discovered that by suitable agitation or stirring of the varnish and abrasive-grain mixture while in a fluid state, air bubbles in large numbers may be entrapped within the fluid and, if the mixture is then immediately applied and allowed to harden at a properly controlled temperature, these bubbles will persist in the hardened abrasive-supporting medium as a number of pockets or voids therein. As these pockets become exposed to the wearing surface, they serve to hold a supply of cooling or lubricating liquid used in grinding and also provide clearance for waste material (see Fig. 8). Such a surface is less likely to glaze and has a higher cutting efficiency than a dense unbroken surface lacking such pockets and is believed to be an entirely novel application of this invention and useful independent of other features herein described.

In another aspect the invention proposes the application of abrasive surfaces to odd or unusual shaped wheels or cutting tools, where the wheel or tool itself is expensive to make, before which purposes, as well as for others, the fabric layer 12 may be omitted, and the coating 14 may be applied directly to the surface 11. In this form of the invention, the use of fibrous material appears to aid materially in the operation of the wheel.

The fibrous strands strengthen the varnish or lacquer and make it less likely to chip or scale off in large pieces.

The use of a knurled, serrated or corrugated surface 11 upon which the abrasive-containing elements are to be laid presents, in one aspect, a special feature of this invention which is believed to be novel. Such irregularities in the surface produce roughing and irregularities in the ultimate grinding surface produced by means of this invention. Preferably the ridges and hollows of the corrugations should lie at an angle to the direction of cut of the tool when in use, so that the cutting is performed by diamonds riding on the high points of the ridges, and between these diamonds there are slight hollows. The provision of such hollows enable the use of larger diamond fragments at the cutting points, with resultant faster rate of cutting.

Abrasive surfaces which are smooth have hitherto had to rely upon constant wastage or disintegration of the grinding surface itself to compensate for glazing or smearing effects. But by the provision of hollows or pockets as suggested in the present invention the tendency to smear or glaze is controlled in a different way, and accordingly the varnish used may be tougher, and the density of diamonds supported in the abrasive surface may be greater since it will not, in that form, be so dependent on the grit of the diamond to perform for constant rate of breakdown of the surface in order to clear it of glazing or smearing particles. Thus, the valleys or depressions or pockets mentioned make it possible to operate the wheel with less loss of diamond dust and accordingly with greater economy.

A further feature of this invention consists of the use of the coating material 14 for the restoration or repair of partially worn diamond wheels. The coating material 14 may be sprayed or brushed upon a partially worn surface originally made in accordance with this invention (e.g. Figure 7) or upon a diamond-containing surface made in accordance with any of the methods heretofore known in the art including diamond-filled "Bakelite" layers. For example, referring to Figure 10, a worn abrasive wheel surface 16 having a groove 16' formed therein may be repaired and restored to good cutting condition by filling the groove with coating material 14, or of desired characteristics if built up with the original grinding surface 11. Prior to the present invention the only known way to restore such wheel was to grind it down to a fresh surface indicated by the dotted line 11, 17 in Figure 10, with attendant large loss of diamond value and displacement of precision adjustments. By means of the present invention the groove 16' is filled till the whole abrasive surface is restored to its original level, no diamond material is necessarily lost, and all original precision adjustments are maintained.

In still another aspect, this invention proposes the building up of a substantial depth of abrasive material containing diamonds by the superposition of a plurality of fabric layers 12. In this event, while the varnish of the final coating 14 (see Figure 7) is still wet or tacky, a second layer of the material 12 is laid thereon and pressed down. This layer may then be filled with diamond dust in the same manner as hereinabove described, and another coating 14 applied thereover. This may be repeated as many times as desired until a surface is built up of the desired depth. In this way diamond wheels may be built up having diamond-charged surfaces of substantial depth, where the main requisite in the use of the wheel is that it shall have a long-wearing life.

In still another aspect, the present invention proposes an abrasive material easily attachable to any surface and adapted to convert such surface into a high-class abrasive surface. For this purpose fabric 12 may be impregnated or loaded with diamond dust and the surface then treated with the coating material 14 prepared as above described, but without first causing fabric 12 to adhere to a metal surface. In this way a portable, ready-to-use, diamond-containing abrasive surface may be kept available in sheet form, may be cut to the desired size and may be applied by means of suitable adhesive to any wheel or tool as needed.

It is to be understood that changes and variations in the methods and constructions specifically described and illustrated are contemplated within the spirit and scope of our invention as claimed and our invention is not to be construed as limited to the exact details of methods or constructions herein described and illustrated.

We claim:

1. The method of forming an abrasive containing matrix upon a peripheral surface of a high-speed grinding wheel which comprises forming a series of shallow closely-spaced parallel grooves and ridges in said surface of said wheel, adhesively securing a layer of fibrous material upon and across said grooved and ridged surface, intermixing abrasive grains with and among the fibres of said fibrous material and to a substantial depth therein, after the said layer has been secured in place, and securing the inter-
mixed grains and fibres in fixed relation to each other by means of a hardening varnish.

2. A grinding wheel for high speed grinding operations having an abrasive-containing matrix of appreciable depth adhesively secured to a hard surface of said wheel, said matrix comprising a plurality of preformed sheets of fibrous material each sheet containing diamond grains intermixed with the fibrous material thereof in a predetermined proportion throughout substantially the whole thickness of said sheet, and hardened varnish occupying the interstices between said grains and said fibres throughout substantially the thickness of said sheets and serving to secure said sheets together, whereby fibres and abrasive grains continue to be presented at the grinding surface in said predetermined proportion at all times as the abrasive-containing matrix wastes away through wear.

3. A grinding wheel for high speed grinding operations having a hard surface with irregularities therein, an abrasive-containing matrix of appreciable depth adhesively secured to said surface, said matrix including at least one preformed sheet of fibrous material containing abrasive grains intermixed with the fibrous material thereof substantially throughout the thickness of said sheet, and hardened varnish occupying the interstices between said grains and said fibres substantially throughout the thickness of said sheet, whereby fibres and abrasive grains continue to be presented at the grinding surface at all times as the abrasive-containing matrix wastes away through wear.

4. The method of building up an abrasive-containing matrix on a peripheral surface of a high-speed grinding wheel, which comprises adhesively securing a layer of dry fibrous material upon a hard surface of said wheel, incorporating diamond grains and a liquid varnish capable of hardening into the interstices between the fibres of said layer after the latter has been secured upon said wheel, and causing said varnish to harden.

5. The method of building up an abrasive-containing matrix on a peripheral surface of a high-speed grinding wheel which comprises adhesively securing a layer of dry textile fabric upon a hard surface of said wheel, sprinkling substantially moisture-free diamond grains upon the exposed surface of said fabric, and after the same has been secured in place upon said wheel, mechanically working said grains into the interstices between the fibres of said fabric while the latter is substantially dry, then applying to said fabric a liquid varnish capable of hardening therein, and causing said varnish to harden.

6. The method of building up an abrasive-containing matrix upon a peripheral surface of a high-speed grinding wheel which comprises forming irregularities in said surface, adhesively securing upon said surface a preformed sheet of fibrous material, incorporating diamond grains and a hardening varnish with and among the fibres of said sheet and to a substantial depth within said sheet, after the latter has been secured in place upon said wheel, and causing the varnish to harden.

7. The method of building up an abrasive-containing matrix upon the surface of a high-speed grinding wheel which comprises forming irregularities in said surface, securing upon said surface of the wheel successive preformed sheets of fibrous material, intermixing abrasive grains and a hardening varnish with and among the fibres in each sheet and to a substantial depth therein before applying a succeeding preformed sheet thereon, and causing the varnish to harden before the succeeding sheet of fibrous material is applied.

8. A grinding wheel for high speed grinding operations having a hard surface with irregularities therein, an abrasive-containing matrix of appreciable depth adhesively secured to said surface, said matrix comprising a plurality of preformed sheets of fibrous material each containing diamond grains intermixed with the fibrous material thereof in a predetermined proportion, and hardened varnish occupying the interstices between said grains and said fibres substantially throughout the thickness of said sheet, whereby fibres and abrasive grains continue to be presented at the grinding surface in said predetermined proportion at all times as the abrasive-containing matrix wastes away through wear.

9. The method of building up an abrasive-containing matrix upon a peripheral surface of a high-speed grinding wheel which comprises adhesively securing a dry layer of glass fibre material upon a hard surface of said wheel, incorporating substantially moisture-free diamond abrasive grains among the fibres of said fabric layer secured in place, the latter having been secured upon said wheel by mechanically working said grains into the interstices between the fibres while the same are substantially dry, applying to said glass fibre material a liquid varnish capable of hardening therein, and causing said varnish to harden.

10. The method of building up an abrasive-containing matrix upon the surface of a high-speed grinding wheel which comprises securing upon a surface of said wheel successive preformed sheets of glass fibre material, incorporating abrasive grains with and among the glass fibres in each sheet and substantially throughout the whole thickness of said sheet before applying a succeeding sheet thereon, and securing the intermixed grains and glass fibres of each sheet in fixed relation to each other by means of a liquid hardening varnish applied before the succeeding sheet of glass fibre material is applied, and causing the varnish to dry and harden.

11. A grinding wheel for high-speed grinding operations having an abrasive-containing matrix of appreciable depth adhesively secured to a hard surface of said wheel, said matrix comprising a plurality of preformed sheets of glass fibre material each sheet containing abrasive diamond grains intermixed with the glass fibres thereof in a predetermined proportion throughout substantially the whole thickness of said sheet, and hardened varnish occupying the interstices between said grains and said glass fibres, whereby glass fibres and abrasive grains continue to be presented at the grinding surface in said predetermined proportion at all times as the abrasive-containing matrix wastes away through wear.

12. A grinding wheel for high-speed grinding operations having an abrasive-containing matrix of appreciable depth adhesively secured to a hard surface of said wheel, said matrix comprising at least one preformed sheet of glass fibre material containing abrasive grains intermixed with the glass fibres thereof substantially throughout the thickness of said sheet, and hardened varnish occupying the interstices between said grains and said glass fibres substantially throughout the thickness of said sheet, the abrasive grains being in excess of the varnish, whereby glass fibres and abrasive grains continue to be...
presented at the grinding surface at all times as the abrasive-containing matrix wastes away through wear.

13. The method of building up an abrasive-containing matrix upon a surface of a high-speed grinding wheel which comprises securing upon said surface a preformed sheet of glass fibre material, intermixing diamond abrasive grains and a liquid varnish with and among the glass fibres of said sheet and to a substantial depth within said sheet after the latter has been secured in place upon said wheel, and causing the varnish to harden.

14. A grinding wheel for high-speed grinding operations having a hard periphery containing a series of parallel grooves and ridges formed in the surface thereof, an abrasive-containing matrix of appreciable depth adhesively secured to said hard surface across the grooves and ridges thereof, said matrix comprising a plurality of preformed sheets of glass fibre material superposed one upon another, each sheet containing abrasive grains intermixed with the glass fibres thereof in a predetermined proportion throughout substantially the whole thickness of said sheet, and hardened varnish occupying the interstices between said grains and said glass fibres whereby glass fibres and abrasive grains continue to be presented at the grinding surface in said predetermined proportion at all times as the abrasive-containing matrix wastes away through wear.

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