United States Patent

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[54] BORON RESIN CUTOFF AND ABRASIVE WHEEL

6 Claims, 9 Drawing Figs.

[52] **U.S. Cl.** **51/207,** 51/401
[51] **Int. Cl.** **B24d 5/12,** B24d 11/00
[50] **Field of Search** ..... 51/401-—404, 206—209, 297

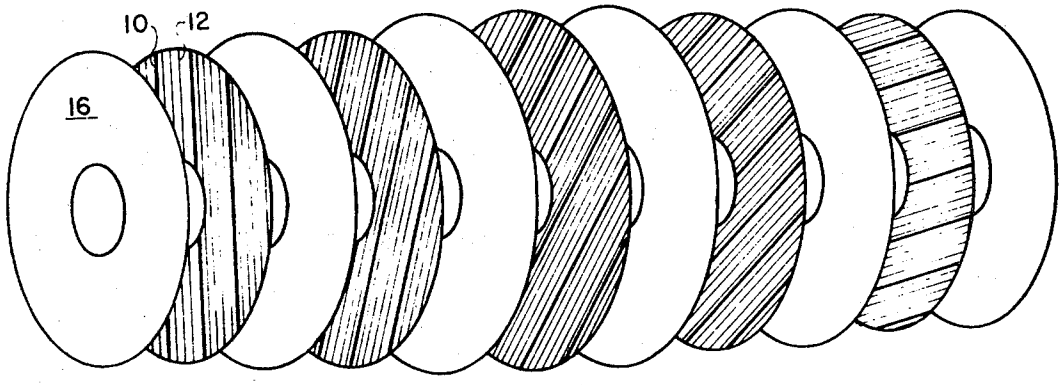
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ABSTRACT: A combination of materials and method of using them in the forming of extremely long wear life and breakage resistant abrasive tools such as cutoff and grinding wheels. This invention utilizes superindurate materials such as boron, boron nitrides or boron carbides as the incorporated abrasive material. The several methods for incorporation of these abrasive materials include lamination of filamentous tape containing the chosen abrasive and spinning or casting a tool of the desired shape from a resinous matrix containing fibers of the chosen abrasive.



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3 Sheets-Sheet 1

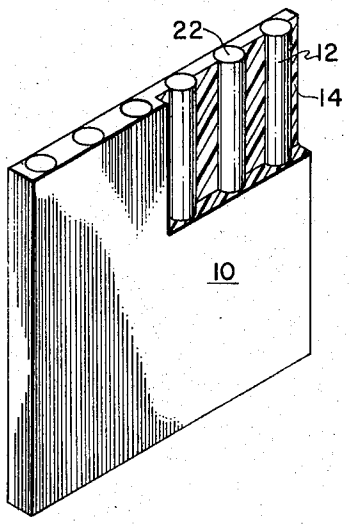


Fig 1

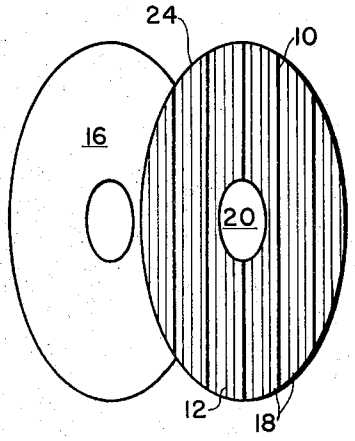


Fig 2

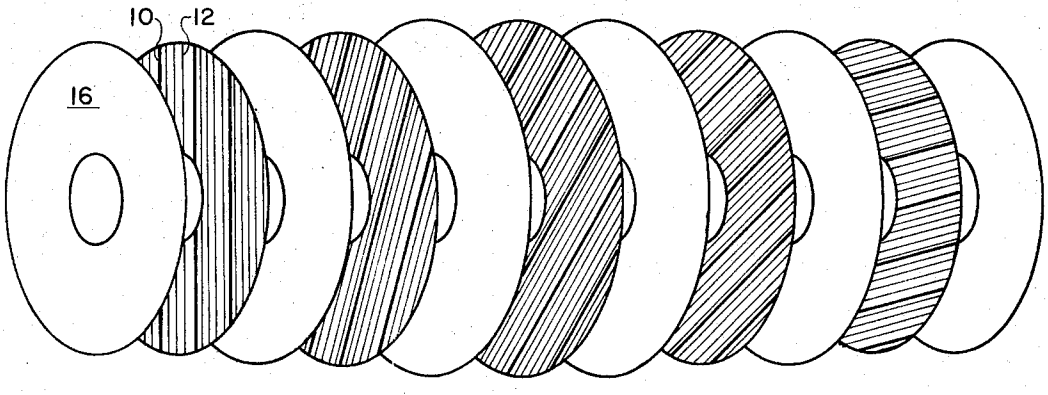


Fig 3

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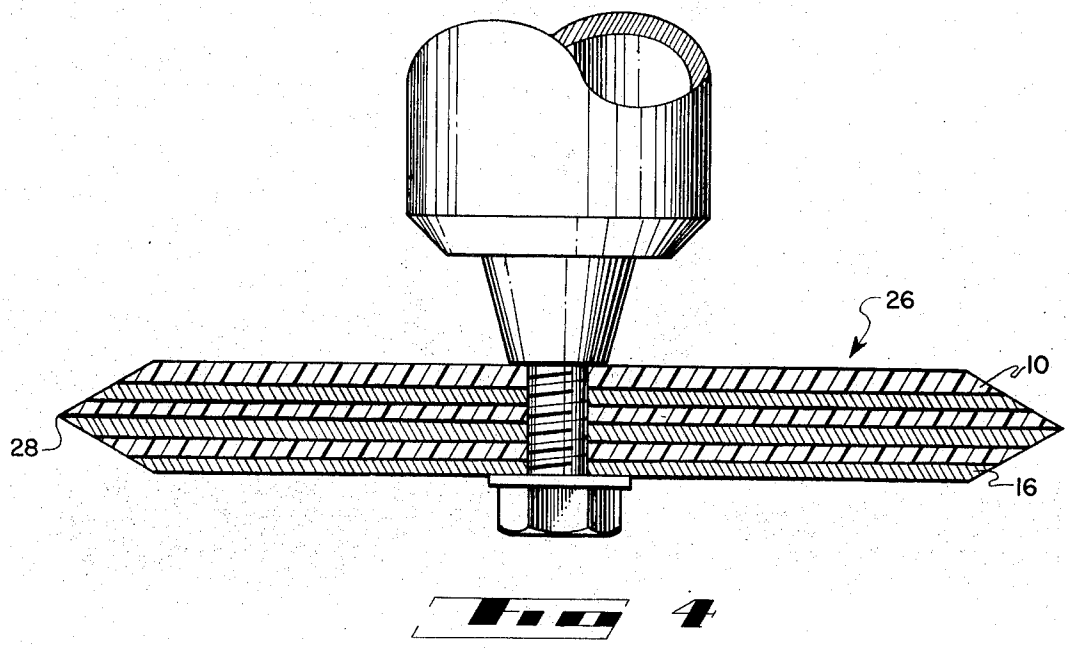


Fig. 4

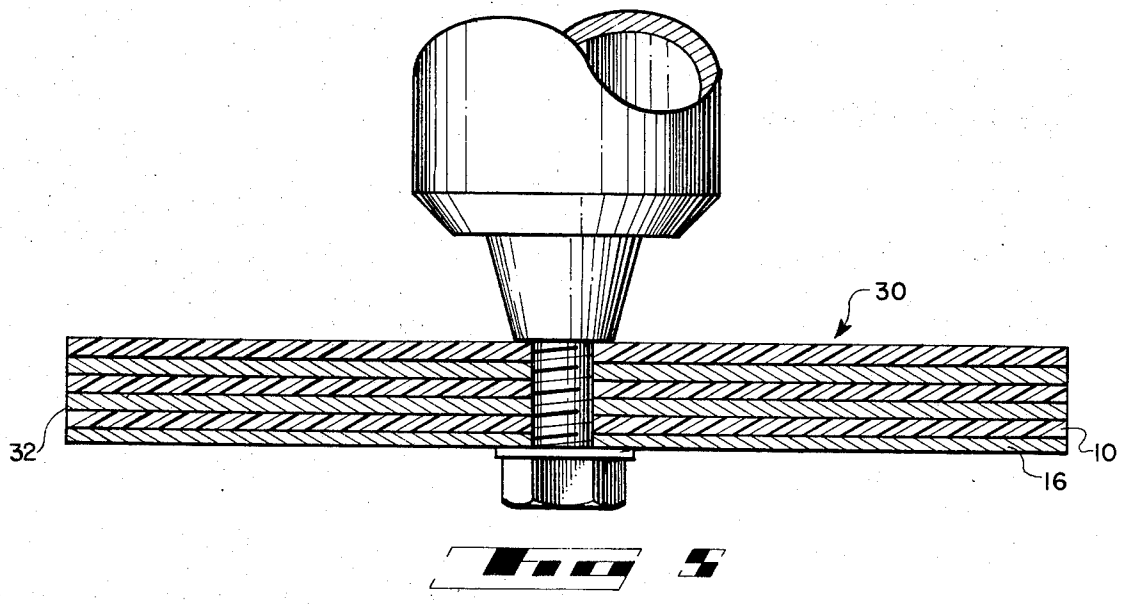


Fig. 5

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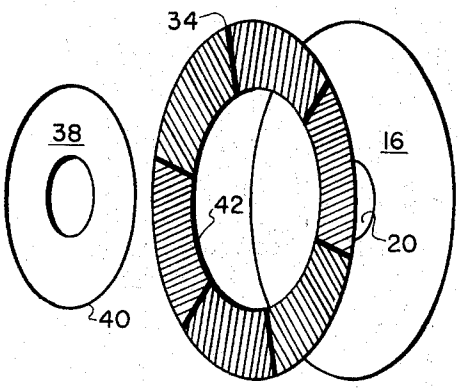


Fig. 6

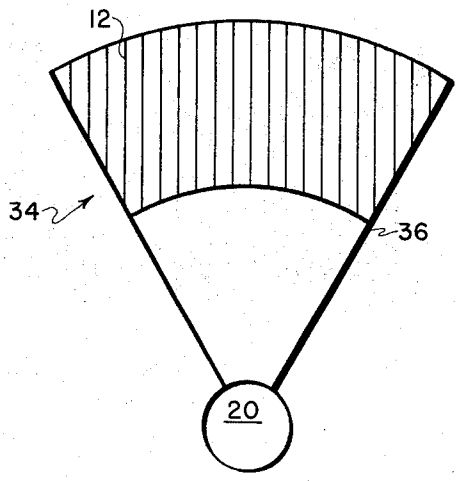


Fig. 7

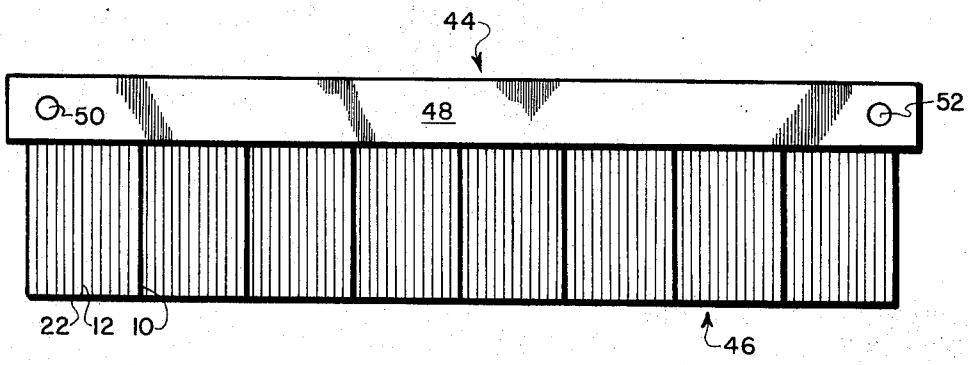


Fig. 8

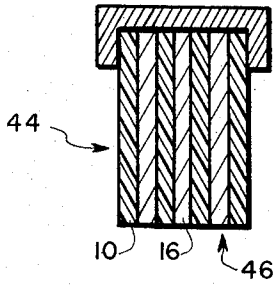


Fig. 9

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BORON RESIN CUTOFF AND ABRASIVE WHEEL

The present invention relates generally to abrasive tool applications.

More particularly, this invention relates to a method of producing very hard, grinding and cutoff wheels which are highly resistant to wear and breakage.

The long life expectancy possessed by the tools provided by this invention offers a significant reduction in maintenance and replacement costs with the accompanying resultant of more economical operation.

Operational safety is enhanced since the tools formed by this unique combination of materials and method of fabrication herein disclosed have a marked resistance to breakage. This resistance to breakage results in fewer workshop accidents thus increasing overall shop efficiency and maintaining desired continuity of production.

PRIOR ART

Grinding and cutoff wheels are presently produced by several well-known and long-utilized methods. One of these methods consists of bonding selected abrasives to a tool formed of a suitable wear resistant material capable of effectively retaining the abrasive. Another method of forming such tools is by casting the chosen abrasives into the basic retaining material. Frequently this type of tool is formed by a combination of bonding and casting.

The abrasive materials most commonly used in the present art are abrasive oxides and carbides which are cast in or bonded to a retaining material, such as a resin.

Several disadvantages are inherent in the tools formed by presently used methods and materials. One of the most prevalent disadvantages is the tendency of the abrasive materials to "pull out" when in use with hard materials causing rapid deterioration of the cutting wheel or tool.

Another disadvantage of currently used tools is their brittleness, thus an inherent susceptibility to breaking. This breakage not only increases production costs but creates an undesirable safety hazard.

The present invention obviates these and other disadvantages of presently known tools through provision of an extremely hard fibrous material in filament form, particularly boron, as the incorporated abrasive material. This utilization of boron filaments provides the desired minimization of wear and is far superior to presently employed particulate material. Boron, boron nitrides and boron carbides are commercially available in tapes of various widths. Utilization of such tapes simplifies fabrication, assures uniform distribution and discriminate positioning of fibers and provides improved retention of the abrasive filaments.

Use of the word "boron" in this specification is intended to include boron nitrides, boron carbides, or any material of similar or useful hardness which is susceptible to use on resinous tapes such as are referred to in this specification.

The term "boron filaments" as hereinafter used in this specification is intended to be generic in nature and inclusive of all forms of boron which are relatively long in length as compared to their diameter. The term "fibers," which is to be included within the generic class of filaments, is used to denote a filament which is comparatively short.

The salient object of the present invention is to provide grinding wheels and cutoff tools that are of improved efficiency over presently known tools utilized in industry.

A particular object of this invention is to provide a feasible means of utilizing filaments of boron, boron nitride, or boron carbide as the incorporated abrasive.

Another object of the invention is the provision of a long life, effective breakage resistant cutting tool which may be economically fabricated by several methods including laminating (or building up in layers), spinning, casting, heat bonding, pressure bonding, or a combination of heat and pressure bonding.

A further object of the invention is the provision of a long life, nonbrittle, breakage resistant cutting or abrading tool.

A still further object of the present invention is to provide an economical, effective cutting tool which is safe to use.

Another object of this invention is to provide a cutting edge of superior abrasive quality which is simply and economically fabricated.

Other objects and advantages of this invention will become readily apparent from a consideration of the appended drawings and following description, wherein the constructional form of the invention is disclosed. It should be further noted that the terms and expressions employed herein are terms of description and not limitation. No intention of excluding any equivalents of features shown or described or portions thereof should be ascribed thereto, recognition being given to the fact that various modifications are possible within the scope of the invention claimed.

Boron is most specifically referred to throughout applicant's specification but is not to be construed as limiting the use of other similar superindurate materials.

The drawings are illustrative of desired methods of fabrication of the materials suggested, wherein:

FIG. **1** is an exaggerated isometric view with portion thereof cutaway to show alignment of the boron filaments within the resin tape;

FIG. **2** is an exploded isometric view illustrating one method of fabrication wherein boron tapes are laid in strips to make up a layer of the cutting tool;

FIG. **3** is an exploded isometric view of the final cutting tool fabricated by the method illustrated in FIG. **2** and showing relative alignment of the boron filaments in each layer;

FIG. **4** is an elevated sectional view of a sharp-edged cutting tool illustrating the relationship of various layers of the material and indicating one method for attaching the cutting tool to the power source;

FIG. **5** is an elevated sectional view of a blunt-edge shaped cutting tool;

FIG. **6** is an exploded isometric view illustrating another method of fabrication wherein segments of boron tape are cut into desired shapes and applied around the outer edge of certain layers of the cutting tool;

FIG. **7** is an elevational view showing an enlarged segment of the boron resin tape utilized in fabrication of the cutting tool by the method illustrated in FIG. **6**;

FIG. **8** is an elevational view of the abrasive tool shown in cross section in FIG. **9** indicating one suggested means for mounting the abrasive device; and

FIG. **9** is an elevational cross-sectional view illustrating another method for construction of an abrasive tool.

Referring now to FIG. **1**, an isometric sectional view of a piece of boron resin tape **10**, wherein the relationship of boron filaments **12** and matrix material **14** within the tape **10** is shown. It is to be noted that the filaments **12** are spaced which spacing is critical in most "structural" uses made of boron tape. It is usually desirable that the boron filaments **12** not be in contact with one another since contact between them would permit unwanted transfer of stress with resultant unequal stress distribution. This unequal stress leads to uneven wear and undesirable breaking of the filaments with characteristic shortened life expectancy of the part fabricated from boron.

Boron resin tape **10** is commercially available from multiple sources in desired widths and spacing parameters. This commercial tape is usually constructed and used so that spacing of the filaments is critical, and in most applications herein involved, uniform or equal spacing is generally desired since more equal wear of the concerned tool would normally result.

However, the application made of the boron in accordance with the present invention does not necessarily require critical spacing of the filaments. As a matter of fact, some applications may be more efficient if the filaments are, for instance, concentrated in one area of the tool.

Thus, spacing of the filaments **12** is not always critical in the fabrication contemplated herein, but there may be tools fabricated by the method disclosed herein where equal, critical spacing may be desirable.

FIG. 2 is an exploded isometric view indicating one preferred method for construction of the cutting tool in accordance with the present invention. The fabrication method utilized by applicant consists of building the tool up in alternating layers of spacer material **16** and boron resin tape **10**. This first preferred method of construction contemplates an organic resin layup of alternating layers of a pliable spacer material **16**, such as a woven nylon or rubber, and boron resin tape **10**. The layup may be pressure bonded to form the cutting tool with or without heat, depending upon the resin selected for the fabrication. The boron tape tool of the present invention is a considerably more efficient cutting tool than the currently used abrasive oxides and carbides. The filaments **12** are better anchored than present abrasives and consequently cannot be pulled off the wheel as can those conventional abrasives presently utilized. Additionally, the length of the filaments **12** contained in the tape afford better, more secure, anchoring of the filaments **12** as well as a continuous replenishment of the working surface.

Boron resin tape **10** is laid on spacer material **16** either in one step, by using a width of tape equal to the diameter of the spacer material **16**, or in plural parallel strips **18** as indicated in FIG. **2**. The boron resin tape may then be trimmed, i.e., either "dressed" or "cut" to the desired dimensions. It is more economical to lay the tape **10** in relatively narrow strips **18** than to utilize tape of a full diameter width matching spacer material **16** since obviously less tape **10** is wasted by this process. Center hole **20** may be blanked out by use of a dinker die, or similar tool effective for accomplishment of this step.

It is to be noted that the actual cutting capability is provided by the edges **22** (FIG. **1**) of the boron filaments **12** which are exposed as at **24** on the extremities of boron resin tape **10**. Laying boron resin tape **10** in parallel strips **18**, as indicated in FIG. **2**, obviously does not provide the desired cutting edge around the entire periphery of the cutting tool. This is so because the most effective cutting capability is attained when the protruding tips **22** of the boron filament **12** (see enlargement in FIG. **1**) are in contact with the surface to be abraded and little or no effectiveness results when the filaments **12** are in contact along their longest axis.

The method for obtaining the desired cutting edge, i.e., tips of boron filament protruding from the cutting tool around the entire periphery of the tool, is illustrated in FIG. **3** wherein it may be noted that the alternate layers of boron resin tape **10** are systematically laid so that the filaments **12** of succeeding layers are at an angle to one another. Thus when all layers of spacer material **16** and boron resin tape **10** are bonded together there will be boron filaments **12** located at and protruding from the entire outer periphery of the completed cutting tool so as to present an abrading face of exposed boron filament tips at all points of contact during the cutting process. Were all layers of boron resin tape **10** laid so that the filaments **12** were parallel, the wheel so formed would tend to split off due to the strippage of filaments. The best abrading device is one that has the filament tips approximately perpendicular to the face to be abraded.

Referring now to FIG. **4**, there is illustrated a pointed edged finished cutting tool **26**. Pointed or working edge **28** may be formed by laying up the alternating layers of spacer material **16** and boron resin tape **10** in successively smaller diameter layers from the center of the tool so as to form work edge **28** from the larger diameter layers located in the center of the tool as suggested in FIG. **3**. It should be further noted at this point that the larger diameter layers need not be located in the center, it is conceivable that it would be desirable to have work edge **28** formed so as to be located at either edge of the tool, for instance, or any other position desired.

FIG. **5** is illustrative of a cutting tool **30** wherein the work surface **32** is blunt, and is formed by laying up layers of spacer material **16** and boron resin tape **10**, each layer being of the same diameter.

The pointed edged finished cutting tool **26**, shown in FIG. **4**, may also be formed by building up a blunt-edged finished cutting tool such as **30**, as shown in FIG. **5**, and then dressing it to a point at the work surface with a diamond tool, or some other tool sufficiently hard to shape the boron. It is noted, however, that boron's hardness renders such shaping difficult. Boron is extremely hard, having a hardness rating of 9.3 on Mohs' hardness scale, any shaping is therefore required to be accomplished by a material with a higher hardness rating.

Choice of finished tool configuration, i.e., pointed work surface **28** (FIG. **4**) or blunt work surface **32** (FIG. **5**) is dependent upon the manufacturer's desire and determined by the ultimate use to be made of the finished cutting tool. For instance a pointed-edge tool **26** would perhaps be preferred in some applications since it is possible to obtain a more precise starting point.

The preferred method of fabrication disclosed by the present invention consists in laying up the boron material in these resinous mats with normally alternate mats of a tough, wear resistant spacer material which serves to increase wear resistance and aid in retention of the abrasive material hence providing longer tool life. The layers of boron need not necessarily be alternate, but alternating layers would normally be preferred since a more uniform cutting face would be presented to the surface to be cut. A further sought after result of the presently proposed method is resistance to breakage. This feature of breakage resistance is accomplished because of the less brittle material, such as a pliable resin, utilized in production of the tool.

Referring now to FIG. **6**, a second preferred method of fabrication is illustrated. In this method, segments of boron resin tape **34** are affixed to a shaped section of spacer material **16**. These shaped segments **34** of boron resin tape **10** are best illustrated by reference to FIG. **7**, wherein an enlarged view of segment **34** is shown. The placement of boron filaments **12** in relation to the individual segments is apparent, and it should be noted that, as in the previously explained method of fabrication, the "proper" spacing of the boron filaments **12** normally desired is readily obtained through use of the tape **10**.

Segment **34** may be cut or stamped from a strip of boron resin tape **10** in the desired size and at the desired angle. The angle of edge **36** is dependent upon the diameter of the cutting tool desired to be formed and relative size of the segment.

Referring still to FIG. **6**, it becomes apparent that segments **34** are placed adjacent to one another and to the outer edge of the cutting tool. Boron filaments **12** (see FIG. **7**) are thus aligned approximately radially outward as though extended through the center **20** of the cutting tool.

In reference to the embodiment shown in FIG. **6**, it is seen that to maintain uniform thickness across the tool being formed a supplemental inner spacer **38** or filler should also be positioned so that its periphery **40** matches the circle formed by the inner ends **42** of segments **34**. This inner spacer **38** serves to fill a gap and should be of the same thickness as the segments of boron resin tape **34** to maintain the desired uniform thickness across the entire tool. Obviously one of these spacers **38** is needed each time a layer of boron resin tape segments **34** is used.

As in the previously described method, the cutting tool may be fabricated to a pointed edge, left uniform, i.e., blunt edged, or fabricated to a blunt edge and "dressed" to a pointed edge.

Referring again to FIG. **1**, the resin tape **10** in this invention is normally made up of a resin matrix **14** in a dormant state and prevented from curing by storage at subzero temperatures. The resin **14** is of a tacky or sticky consistency and lends itself well to use in applications such as are described above.

Fabrication of boron-cutting tools by the above-described methods is preferred because these methods produce superior quality tools, but the use of boron as an abrasive material in the context of this invention is not limited to tools laminated with boron tapes. It is also feasible to form such tools by "-spinning" and "casting."

In the "spinning" method a fluid composite of resin and chopped boron fibers (as distinguished from filaments which are longer and are contained in resin tape form) is mixed, then

spun in a mold so that centrifugal force is exerted on the mixture. The result of this force is to force the chopped boron fibers to the outer extremity of the mold, then heat or pressure, or a combination of the two, is applied to harden the final tool to the shape of the mold used. Not all of the fibers contained in the mold will be aligned so as to present a cutting edge or face of maximum efficiency but a sufficient percentage will be. The resultant tool, while sufficiently effective for most purposes, does not have the optimum abrasive characteristics obtainable through the use of boron in resin tape form because the fibers are not as long, hence less effective retention is possible, and all of the fibers are not fully utilized.

"Casting" is another very feasible method of production for these boron tools, In this process, chopped or random-sized fibers are mixed in a mold, then cast by heat, pressure or both, dependent upon the base material chosen. This is a simple method and is perhaps best utilized where a wide layup would be necessary. As in the "spinning" method, maximum efficiency is not obtained, but less labor costs may be entailed and the savings effected may justify use of this method in some applications.

Referring now to FIG. **8** there is shown a "saw" type abrasive tool **44** which is another form in which applicant's invention may be manufactured.

In this fabrication method alternating layers of boron resin tape **10** are laminated with layers of spacer material **16** (as better seen in the cross-sectional view presented by FIG. **9**), and subsequently bonded to form the work surface **46** of the abrasive tool **44**. The boron resin tape **10** is so positioned that boron filaments **12** (FIG. **8**) contained in the boron resin tape **10** will present their protruding tips **22** (as seen better in FIG. **1**) approximately perpendicular to the surface to be cut or abraded.

FIG. **8** illustrates one suggested method for mounting the saw-type abrasive tool **44** in a support member **48**. Holes **50**, **52** may be provided to enable affixing to a power source which would provide vibratory or oscillating movement to provide a sawing motion to the abrasive tool **44**. It is to be noted that this abrasive tool **44** need not have a saw-toothed cutting edge. Obviously, the segments of boron resin tape **10** may be "lapped" through offsetting tape **10** and spaces **16** alternately to obtain more structural rigidity along the length of the tool.

This invention as shown and described in the preceding specification and drawings provides an extremely hard, very wear resistant, grinding and cutoff wheel and a method of fabricating same through an organic resin layup of alternating layers of a pliable material and a boron fiber resin tape. The boron filaments serve the same purpose as the abrasive oxides and carbides of the prior art combined with materially increased efficiency, the filaments offering a better abrasive anchor and are not subject to rapid wear as is the case with the more conventional materials. The plies of flexible material provide support for the boron resin tape and function therewith to provide a strong yet bendable and safe cutoff or grinding wheel. The use of hard fibrous material other than, but of the class of boron, as the wear resistant abrasive of the cutting wheel composite is contemplated.

I claim:

1. A cutting and abrading tool comprising a tool body having a work face, said body comprising essentially a plurality of superimposed laminations of boron fiber resin tape and a supporting and tape-retaining material adhered thereto, said tape laminations oriented so that said boron fibers are at an angle substantially normal to said work face, said body having means for attachment to a motive source.

2. The tool defined by claim **1** wherein said fiber consists of filaments of boron, boron nitride, boron carbide or combinations thereof.

3. The tool defined by claim **1** wherein said body comprises a blade having a work face defined by a substantially longitudinally extending planar surface.

4. The tool defined by claim **1** wherein said body is circular and adapted to abrade on rotational motion thereof, said work face defined by the periphery of said circular body.

5. The tool defined by claim **3** wherein the fiber orientation of said tape lamination is offset directionally from the prior tape lamination fiber orientation.

6. The tool defined by claim **4** wherein at least some of said boron fiber resin tape laminations comprise plural, segmented tape portions each of a length less than the radius of said tool and having nonparallel sides, said sides being substantially contiguous to the sides of adjacent segments.