April 29, 1969 J. H. HAWKES 3,440,773

ABRASIVE CUTTING DEVICE

Filed Aug. 26, 1966

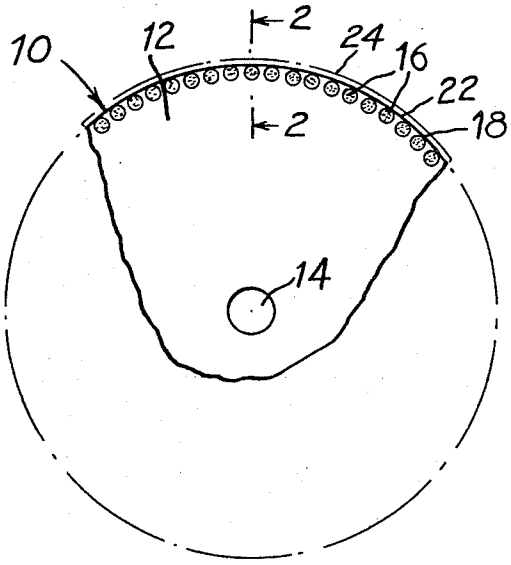

Fig. 1

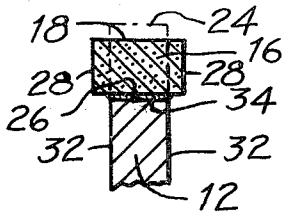

Fig. 2

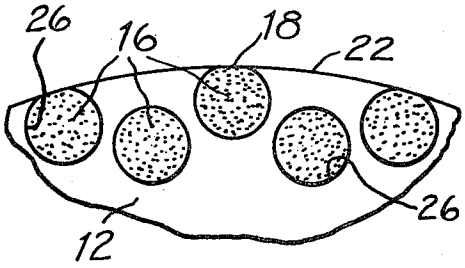

Fig. 3

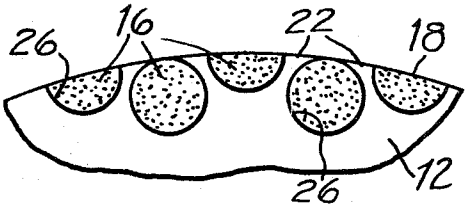

Fig. 4

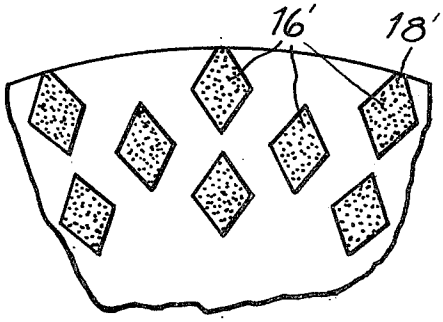

Fig. 5

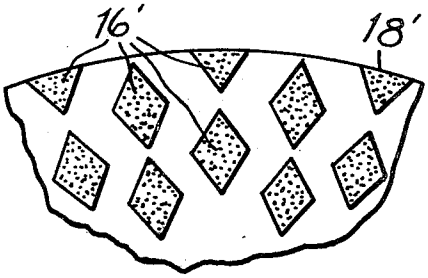

Fig. 6

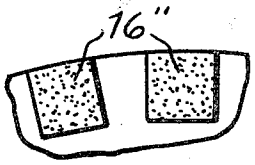

Fig. 7

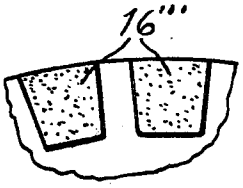

Fig. 8

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ABRASIVE CUTTING DEVICE

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ABSTRACT OF THE DISCLOSURE

Abrasive saw blades having abrasive elements mounted adjacent the outer periphery of a thin circular support; element are abrasive (e.g., diamond) impregnated, thicker than supporting blade, may be arranged in multiple rows, and are particularly adapted for fabrication and bonding to the support by pressure-resistance sintering of elements in place, in apertures in blade, followed by grinding away of periphery of blade to expose abrasive elements.

This invention relates to an abrasive cutting device, and more particularly to the type of abrasive wheel commonly referred to as a cut-off wheel or blade and consisting of a thin circular support with a series of discrete abrasive portions mounted upon the circular support at spaced intervals along its periphery.

The type of cut-off wheel or blade comprising a non-abrasive circular support with a series of abrasive portions mounted around its periphery is well known in the prior art, and typically comprises a circular steel center with spaced radial slots extending inwardly from its peripheral edge and a series of elongated abrasive portions fixedly secured to the peripehral edge of the center between adjacent radial slots therethrough. However, both the manufacture and the use of such cut-off wheels or blades poses several problems.

Considering first the manufacture of high density abrasive portions or segements for such an application consisting of diamond particles in a sintered metal bond or matrix, such segments are subject to about 30% shrinkage and to distortion during the sintering operation, and these factors make it extremely difficult to produce segments within close dimensional tolerances and to the exact shape required. These difficulties are further aggravated by the proportions of a typical elongated segment with one dimension 10 to 20 times as long as the other two dimensions.

Considering now the mounting operation by which the elongated segments are attached to the peripheral edge of the circular center, it is relatively difficult to support and maintain the elongated segment in the required precise position relative to the circular center while the segment is attached thereto by a conventional brazing operation or other suitable mounting technique. Moreover, during the segment mounting operation, it is difficult to avoid exposing the assembly to heat sufficient to degrade the diamond particles and to adversely affect the material in the circular center.

Considering next the use of such cut-off wheels or blades, the substantially elongated relatively hard segments are relatively brittle so that they are easily cracked by forces exerted perpendicular to the plane of the circular center. For the same reason, the impact strength of a cutting edge composed of elongated hard segments is relatively low. Moreover, in a cut-off wheel or blade with a cutting edge composed entirely of about 20 substantially elongated abrasive portions or segments, even relatively small variations in the composition or the physical properties of the respective segments will cause the blade

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to wear out of round in use. Finally, since the substantially elongated segments are commonly secured to the circular center by relatively soft brazed joints extending substantially concentrically of the circular center, the blade may be so badly undercut along these joints that the segments are broken off before they are worn out, especially when the blade is used to cut highly abrasive material.

The present invention contemplates a cut-off wheel or blade configuration incorporating relatively compact abrasive portions or segments, that is segments characterized as compact because their greatest dimension is at most only a few times as large as their least dimension and commonly nearly the same so that such segments encompass a relatively large volume within a relatively small surface.

An object of the present invention is the provision of a cut-off blade incorporating compact abrasive portions or segments which may be manufactured by conventional sintering techniques to the desired precise dimensions and configuration more readily than substantially elongated segments.

Another object of the present invention is the provision of a cut-off blade incorporating compact abrasive portions or segments more resistant to failure under side loads substantially perpendicular to the circular center of the blade than are substantially elongated segments.

Still another object of the present invention is the provision of a cut-off blade incorporating a large number of compact abrasive portions or segments arranged to cooperate with portions of the circular center extending to the periphery of the blade to form a cutting edge substantially more resistant to impact loads than a cutting edge composed of substantially elongated segments.

Yet another object of the present invention is the provision of a cut-off wheel incorporating a large number of relatively small compact abrasive portions or segments in which any variation in the composition or physical characteristics of the respective segments is so widely distributed that the blade will not wear out of round in use notwithstanding some variation in the properties of the respective segments.

A further object of the present invention is the provision of a cut-off blade incorporating compact abrasive portions or segments so shaped and disposed relative to the circular center of the blade that the relatively soft brazed joints by which the segments are secured to the center will not be undercut sufficiently to substantially shorten the useful life of the blade when the blade is used to cut highly abrasive material.

Still a further object of the present invention is the provision of a cut-off blade incorporating multiple concentric series of compact abrasive portions or segments to provide a cutting edge useful over a substantially greater radial depth on the circular center than can be provided by substantially elongated segments attached to the periphery of a circular center.

Yet a further object of the present invention is the provision of a more versatile cut-off blade incorporating multiple concentric series of compact abrasive portions or segments in which the properties of the respective series of abrasive segments may be varied by varying their compositions to best adapt the blade to various different applications.

A final object of the present invention is the provision of a cut-off wheel or blade incorporating a large number of compact abrasive portions or segments particularly well adapted to the use of known pressure-resistance sintering techniques to form the compact abrasive portions in situ in the circular center with the simultaneous formation of a hard wear-resistant joint between each compact abrasive portion and the circular center.

Other objects and advantages of the instant invention will be apparent from consideration of the following description and the showing in the accompanying drawing wherein:

FIG. 1 is a plan view partially broken away of the preferred embodiment of the instant invention,

FIG. 2 is a section partially broken away, taken on line 2—2 of FIG. 1, showing details of the preferred embodiment of the instant invention,

FIG. 3 is a plan view partially broken away of a modified embodiment of the instant invention incorporating two rows of circular abrasive portions adjacent to the periphery of the circular center,

FIG. 4 is a plan view partially broken away showing the embodiment of the instant invention illustrated in FIG. 1 with the outer row of circular abrasive portions partially worn away,

FIG. 5 is a plan view partially broken away showing another modification of the instant invention with three rows of non-circular abrasive portions adjacent to the periphery of the circular center.

FIG. 6 is a plan view partially broken away of the embodiment of the instant invention illustrated in FIG. 5 with the outermost row of abrasive portions partially worn away,

FIG. 7 is a detailed showing of a modified compact abrasive portion with parallel sides, and

FIG. 8 is a detailed showing of a modified compact abrasive portion with sides disposed radially of the center.

Referring now to the drawing, wherein like reference numerals refer to like or corresponding parts, FIG. 1 shows a cut-off wheel or blade generally designated by the reference numeral **10** including a circular center or support **12** with a central opening **14** by means of which the center **12** can be mounted upon a suitable arbor for rotation about its central axis and including a series of spaced compact abrasive portions **16** each with an outermost working surface **18** coincident with the peripheral surface **22** of the center **12**. The phantom line **24** in FIG. 1 indicates the peripheral edge of the circular blank from which the blade **10** is made in the manner described further below.

Referring now to FIG. 2, each compact abrasive portion **16** is fixedly secured in an aperture **26** through the center **12** located a predetermined given distance from the peripheral edge **24** of the blank from which the blade **10** is made, and each compact abrasive portion **16** is so proportioned that the flat surface **28** perpendicular to the axis of rotation of the blade **10** located at its opposite extremities project equal distances beyond the respective sides **32** of the center **12**. The respective compact abrasive portions **16** are fixedly secured within the respective apertures **26** by any suitable bonding means such as a brazed joint **34** or other suitable bonding agent or the like.

Referring once more to FIG. 1 and also to FIG. 3, the blank with the peripheral edge **24** from which the blade **10** is made is first provided with a series of spaced apertures **26** therethrough and a compact abrasive portion **16** which may be made in the manner described further below is fixedly secured in each of the apertures **26** in the manner described above. Thereafter, the blade **10** is prepared for use by removing the portion of the blank between the peripheral edge **24** and the peripheral surface **22** of the center **12** to expose a working surface **18** at the outermost extremity of each of the compact abrasive portions **16**. This operation may be performed by grinding away the portion indicated or by other suitable machining operations capable of removing sufficient stock from the blank to expose the outer extremities of the compact abrasive portions **16** to form the working surfaces illustrated in FIG. 3.

The embodiment of the instant invention illustrated in FIGS. 3 and 4 in which the blade **10** incorporates two rows or series of compact abrasive portions **16** mutually offset circumferentially of the center **12** and overlapped radially of the center **12** provides a configuration of the instant invention capable of maintaining an effective cutting edge to a radial depth substantially larger than can be provided by relatively narrow elongated segments bonded to the peripheral edge of the center. More particularly, from the showing in FIG. 4, it will be evident that working surfaces **18** will be exposed on the innermost row of compact abrasive portions long before the outermost row of compact abrasive portions is worn away completely.

Referring next to the embodiment of the instant invention illustrated in FIGS. 5 and 6, it should be noted that the several advantages of the compact abrasive portions described herein can be retained when the compact abrasive portions **16** comprising right circular cylinders are replaced with other suitable compact configurations such as the diamond-shaped compact abrasive portions **16'** or other suitable shapes with a corresponding degree of compactness. The embodiment illustrated in FIGS. 5 and 6 also illustrates the use of more than two rows of compact abrasive portions **16'** to further increase the radial depth over which an effective cutting edge is maintained.

While the instant invention is clearly applicable to cut-off blades incorporating centers made from various metallic and nonmetallic materials and to compact abrasive portions of various different compositions, it is particularly well suited to the type of blades incorporating steel centers and abrasive portions or segments comprising diamond particles immobilized in a metal bond which may be produced by sintering or otherwise reducing a mixture of diamond particles and metal particles to a rigid cohesive structure of the desired size and shape.

In a cut-off blade incorporating multiple concentric rows or series of compact abrasive portions, the composition of the compact abrasive portions in the respective rows may be varied to best adapt the blade for a given operation on a particular material. For example, the blade may be adapted to cut a hard material efficiently and to produce a relatively smooth finish on the cut surfaces at the same time by incorporating in the blade an outermost row of compact abrasive portions consisting of a relatively high content of diamond particles and a relatively soft bond or matrix to provide a free cutting action for the rapid penetration of the material being cut, and by incorporating at least one additional row of compact abrasive portions concentric of and within the outermost row with compact abrasive portions comprising a relatively lower content of diamond particles and a very hard bond or matrix effective to produce relatively smooth cut surfaces. In the case of cut-off blades incorporating multiple rows of compact abrasive portions, it will for some applications be preferable to arrange adjacent rows of the compact abrasive portions so that they do not overlap each other radially of the circular center whether or not the adjacent rows of compact abrasive portions are mutually offset circumferentially of the circular center. This non-overlapping configuration of the adjacent rows of compact abrasive portions permits the establishment of separate and distinct cutting zones for the respective rows of compact abrasive particles when the provision of such separate zones is preferred over the overlapping cutting zones established by radially overlapping rows of compact abrasive portions.

In a test comparing the preferred embodiment of the instant invention as shown in FIG. 1 with right cylindrical compact abrasive portions ¼" in diameter to a conventional segmented diamond blade with the same total diamond content at the beginning of the test, the blade constructed as shown in FIG. 1 and described above performed throughout the test with both cutting time and wheel wear closely comparable to those of the conventional segmented blade, and there was no substantial variation in the cutting time for the blade constructed ac-

cording to the instant invention, notwithstanding the fact that the initial cuts were made with minimum exposure of the compact abrasive portions at the working surfaces **18** and the further fact that the final cuts were made with maximum exposure of half worn compact abrasive portions at the working surfaces **18** as illustrated in FIG. 4. Accordingly, this comparison indicated that the extension of portions of the steel circular center to the peripheral surface **22** of the blade **10** provides additional strength for the cutting edge without interfering with the cutting efficiency of the compact abrasive portions as compared to conventional segments. This test also indicated that very substantial variation in the area of the working surface **18** of the compact abrasive portions **16** need not substantially change the cutting time achieved by a blade of the configuration illustrated in FIG. 1, so that the blade can be expected to perform at a relatively uniform cutting rate over its entire useful life.

For some applications it may be advantageous to produce a blade **10** with compact abrasive portions arranged to provide working surfaces with constant areas throughout the life of the blade, and this may be accomplished as shown in FIG. 7 by incorporating in the circular center **12** compact abrasive portions **16″** with parallel side surfaces mounted so that they are symmetrical about spaced radii of the circular center **12**.

For other applications it may be desirable to produce a blade incorporating compact abrasive portions arranged to maintain a constant ratio between the area of the working surfaces of the compact abrasive portions and the area of the circular center **12** exposed along the peripheral surface **22** throughout the useful life of the blade, and this may be accomplished as illustrated in FIG. 8 by incorporating compact abrasive portions **16‴** with side surfaces coincident with spaced radii of the circular center **12**, so that these compact abrasive portions are also individually symmetrical about spaced radii of the circular center **12**.

From the various modifications of the compact abrasive portion described above and illustrated in the drawings, it will be evident that the shape of these portions may be varied widely to suit various requirements all within the essential concept of a compact configuration. For example, a circular abrasive portion may be so modified that it assumes an elliptical or other smoothly contoured configuration, and compact abrasive portions with intersecting flat side portions may include various numbers of flat side portions in various relative dispositions. In addition, the essential characteristics of the compact design can be maintained in a compact abraisve portion symmetrical about a central axis even when the dimension along that axis is relatively shorter than the dimensions in the plane perpendicular to that axis, as may be the case with a button configuration as illustrated in FIGS. 1, 3 and 4 when the diameter of the button is greater than its length along its central axis.

Thus, the instant invention provides a cut-off wheel or blade demonstrably capable of performance fully comparable to that of a conventional segmented diamond blade and also more resistant to the development of an out of round condition with resultant objectionable vibration and chatter, and finally providing a configuration of the abrasive portions or segments and the adjoining portions of the circular center or support which is substantially more resistant to failure than conventional substantially elongated segments.

The description and the accompanying drawings provided herein are intended as exemplary only with the understanding that substantial modifications of the device described are possible within the scope of the present invention as defined by the appended claims.

What is claimed is:

1. An abrasive cutting device comprising

a thin flat circular support symmetrical about a central axis and arranged to be mounted for rotation about its central axis,

a first series of spaced apertures extending from side to side through said circular support each disposed adjacent to the peripheral surface of said circular support and opening onto the peripheral surface of said circular support.

a corresponding first series of discrete compact abrasive portions respectively filling and secured fixedly within said first series of apertures with opposite extremities of said compact abrasive portions projecting beyond the respective sides of said circular support,

each said compact abrasive portion in said first series thereof having a working surface outermost of said center exposed at and substantially coincident with the peripheral surface of said circular support,

at least one additional series of spaced apertures through said circular support located concentrically of said circular support and radially inwardly thereof relative to said first series of spaced apertures,

and at least one additional corresponding series of discrete compact abrasive portions respectively filling and secured fixedly within said additional series of apertures with opposite extremities of said compact abrasive portions projecting beyond the sides of said circular support.

2. A device as described in claim **1**, wherein,

aside from its opening onto the peripheral surface of said circular support, each aperture in said first series of apertures is defined by a smoothly curved perpiheral edge which together with the opening onto the peripheral surface of said circular support encloses a predetermined cross section area,

each compact abrasive portion of said first series of abrasive portions has a corresponding smoothly curved peripheral surface which together with said working surface encompasses the same cross section area,

each aperture of each said additional series of apertures is defined by a smoothly curved peripheral edge enclosing a predetermined cross section area,

and each compact abrasive portion of each additional series of compact abrasive portions has a corresponding smoothly curved peripheral surface which encompasses the same cross section area.

3. A device as described in claim **2**, wherein both said smoothly curved peripheral edge of each said aperture and said corresponding smoothly curved peripheral surface of each said compact abrasive portion are circular.

4. A device as described in claim **1**, wherein,

aside from its opening onto the peripheral surface of said circular support, each aperture of said first series of apertures is defined by a peripheral edge comprising angularly offset straight portions which with the opening onto the peripheral surface of said circular support encloses a predetermined cross section area,

each compact abrasive potrion of said first series of abrasive portions has a corresponding peripheral surface which together with said working surface encompasses the same cross section area,

each aperture of each additional series of apertures is defined by a peripheral edge comprising angularly offset straight portions enclosing a predetermined cross section area,

and each compact abrasive portion of each additional series of compact abrasive portions has a corresponding peripheral surface encompassing the same cross section area.

5. A device as described in claim **4**, wherein both said peripheral edge of each said aperture and said corresponding peripheral surface of each said compact abrasive portion include four intersecting straight portions.

6. A device as described in claim 1, wherein
the respective apertures of each additional series of apertures are offset circumferentially of said circular support from the adjacent apertures of the next adjacent series of apertures located radially outwardly of said circular support,
and the outermost portion of each aperture of each additional series of apertures is located radially outwardly of said circular support beyond the innermost portions of the adjacent apertures of the next adjacent series of apertures located radially outwardly of said circular support.

7. A device as described in claim 1, wherein
each compact abrasive portion of said first series of abrasive portions consists of a first predetermined mixture of abrasive particles and a relatively soft matrix to provide a free cutting action,
and each compact abrasive portion of each additional series of abrasive portions consists of a second predetermined mixture of abrasive particles and a relatively hard matrix to provide a smooth finishing action.

References Cited

UNITED STATES PATENTS

1,063,380	6/1913	Pierce	125—22
1,926,321	9/1933	Turek	51—209 X
2,225,193	12/1940	Benner	51—209 X
2,434,314	1/1948	Felker	51—293
2,564,217	8/1951	Taylor	51—206
2,867,063	1/1959	Metzger	51—209
3,049,843	8/1962	Christensen	51—206
3,307,242	3/1967	Cofran	125—22 X

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