United States Patent [19]

Coes, Jr.

[11] **3,795,078**

[45] **Mar. 5, 1974**

[54] **SEGMENTAL CUT-OFF WHEEL**

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[22] Filed: **Nov. 1, 1972**

[21] Appl. No.: **302,662**

[52] **U.S. Cl.** **51/206.5**
[51] **Int. Cl.** **B24d 5/06**, B24d 5/08
[58] **Field of Search** .... 51/206 NF, 206.4, 206.5

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Primary Examiner—Othell M. Simpson
Assistant Examiner—Marc R. Davidson
Attorney, Agent, or Firm—Walter Fred

[57] **ABSTRACT**

A relatively large high speed thin segmental cut-off grinding wheel has a reusable drive center with a peripheral segment aligning groove between axially spaced opposed side flange portions and equally spaced identical groups of precision tapered locating holes, in at least one of the side flanges. Identical interchangeable, replaceable and detachable composite reinforced abrasive segments are equally spaced around, precisely located, and clamped between the side flanges of the center. Each abrasive segment comprises, a thin non abrasive segment support member including a plurality of precision segment locating holes therein precisely aligned with a group of the tapered locating holes in the side flange portion by a plurality of easily removable and insertable mating tapered segment locating and retaining members extending axially therethrough and threaded into either the opposite side flange portion or into a tapered nut within an opposite tapered hole in the opposite side flange of the center. Resilient members may be compressed in the space between the inner surface of the abrasive segments and the circumferential surface of the center for maintaining the segment in tension and/or compensate for any irregularities or non mating contours in the adjacent surfaces.

10 Claims, 7 Drawing Figures

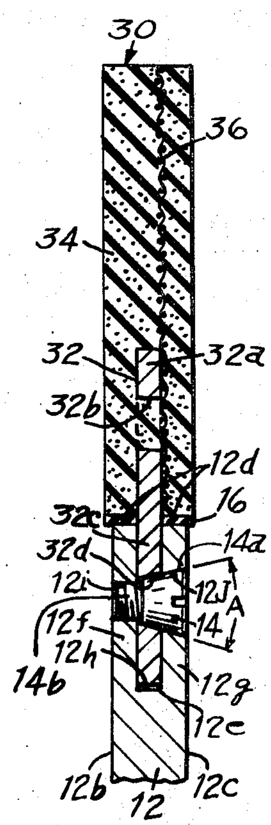


FIG. 1

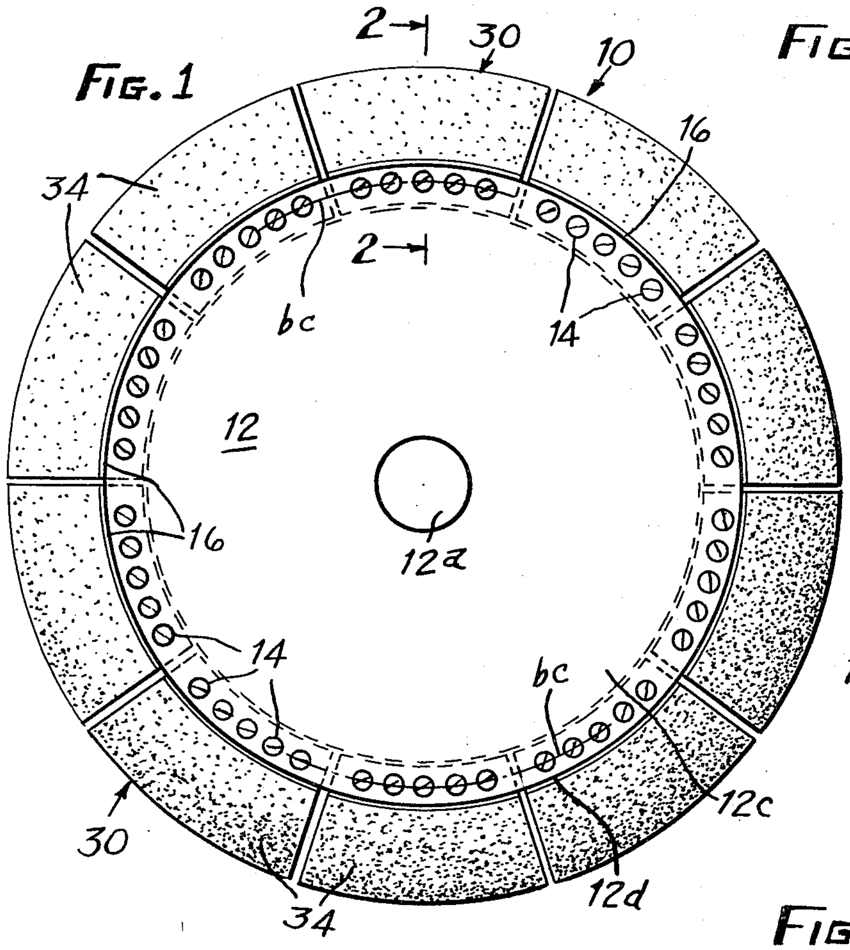
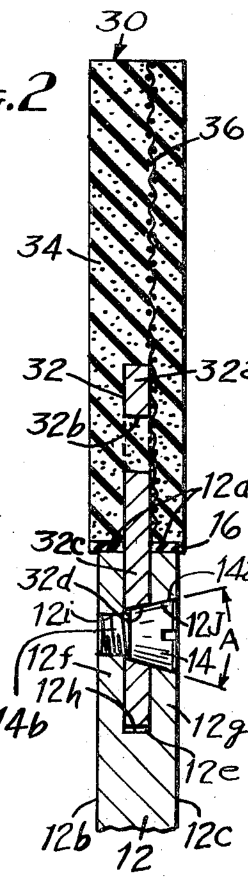


FIG. 2



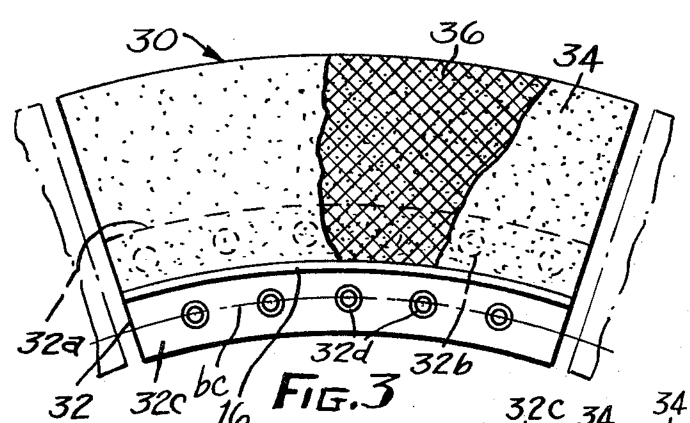


FIG. 3

FIG. 4

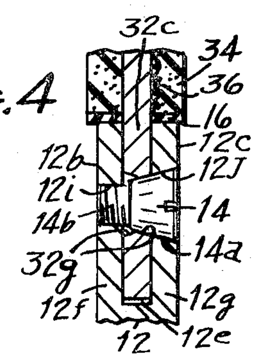
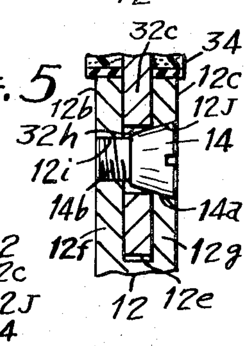


FIG. 5



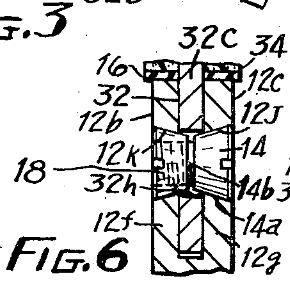


FIG. 6

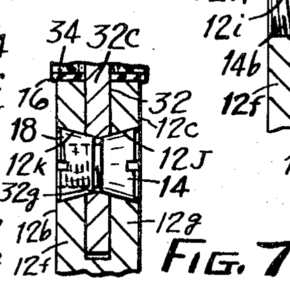


FIG. 7

SEGMENTAL CUT-OFF WHEEL

BACKGROUND OF THE INVENTION

1. Field of Invention

The invention relates to relatively large thin high speed segmental cut-off grinding wheels with a plurality of identical easy and quickly detachable, replaceable and interchangeable arcuate composite abrasive segments thereon and particularly to precision means for quickly and precisely locating and attaching the segments to the reusable drive center.

2. Description of the Prior Art

Heretofore, abrasive segments have been attached to relatively small diameter and seldom reused drive hub or centers by riveting, bolting, brazing and adhesively bonding them to the center. Thus a great deal of time and effort is required to replace worn out segments with new ones. The applicants segmental cut-off wheel differs from the prior art in that both the abrasive segment support members and the reusable center have precisely located segment locating holes axially aligned by the engaging mating tapered surface portion of removable and reusable segment locating and retaining members threaded at one end into the opposite side of the center or a tapered nut therein. In addition the segmental wheel may have resilient members compressed between the abrasive portion of the segment and the circumferential surface of the center for the purpose of resisting side pressure, keeping the segment support member in tension to resist reverse stress and/or compensate for any irregularities in the contour of the adjacent abrasive surface.

Segmental wheels of similar construction are disclosed in a copending application Ser. No. 294,083 entitled "Segmental Cut-off Grinding Wheels" of Joseph J. Paterno, Jr. et al. filed on Oct. 2, 1972. Also, in the following U.S. Pat. Nos. 237,472 issued to Blackburn, Feb. 8, 1881; 3,162,187 issued to Christenson, Dec. 22, 1964; 1,783,729 issued to Larsson, Dec. 2, 1930; 2,092,591 issued to Sohlstrom, Sept. 7, 1937; German Pat. Nos. 530,792 issued to Krug, July 23, 1931 and 1,652,883 issued to Berstecher, Mar. 11, 1971 there are disclosed various prior art grinding wheels of which the Applicant is aware that are similar to but clearly distinguishable from the invention disclosed hereinbelow.

SUMMARY OF THE INVENTION

A thin high speed segmental cut-off grinding wheel of relatively large diameter with a thin reusable drive hub or center adapted with suitable means by which it can be mounted on an arbor and rotatably driven about an axis in the conventional manner. The thin drive center or disc has a narrow peripheral slot or groove extending circumferentially around the center and radially inward from a peripheral surface between opposite sides of the center, a predetermined radial depth to a circular surface at the bottom groove extending axially between opposed spaced side flange portions of the center. There are a plurality of equally spaced identical groups of tapered apertures of identical size and shape spaced around and extending axially through at least one of the opposed spaced side flange portions with the axes of the tapered aperatures situated on the same base circle of predetermined radius from the axis of the center. A plurality of identical, interchangeable, replaceable, and detachable arcuate composite reinforced abrasive segments are equally spaced around the center, each having a thin segment base or support member with a perforated outer radial portion embedded in, interlocked with and resin bonded to a thicker arcuate resin bonded abrasive portion and tongue projecting symmetrically therefrom into the groove between the spaced flange portions of the center. Each tongue portion has a group of identical segment locating apertures, which may be either straight, single tapered or double tapered, axially aligned with the axes of a group of the tapered apertures on the same base circle in the flange portion.

A plurality of identical removable tapered segment locating and retaining members each have a tapered or cone shaped portion engaging the center within mating tapered or cone shaped aperatures and extending axially into the locating aperatures in the tongue portion, which is forcefully engaged, centered on, and precisely positioned thereby, to a portion threaded into either the opposite side flange portion or into a tapered or cone shaped nut in mating engagement with an oppositely tapered surface within a tapered aperture in the opposite side flange portion of the center.

A relatively thin compressible resilient spacer may be provided and compressed between the segments and the center to fill the space, make it unnecessary to true abrasive corner, compensate for radius and other irregularities between adjacent surfaces of the abrasive segment and the circumferential surface of the center, keep the segment support members in tension and help it to oppose side bending forces as well as reverse stress applied thereto.

Abrasive segments are replaced, precisely positioned and clamped in place by removing the tapered segment locating and retaining members and the worn out segment from the center. inserting a new segment abrasive segment, in the groove, reinserting the tapered segment locating and retaining members through the tapered apertures in the center, the locating aperatures in the segment base member, and screwing them tightly into either the threaded apertures or tapered nuts in the opposite flange portion of the center.

Therefore, it is the primary object of the invention to provide a segmental cut-off grinding wheel having a thin reusable center including a peripheral segment aligning groove into which extend segment support members of a plurality of identical interchangeable, replaceable and detachable reinforced composite abrasive segments, and precision tapered segment locating and retaining means for quickly positioning, fastening and clamping abrasive segments to the center.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a view of an assembled segmental cut-off wheel of the invention;

FIG. 2 is an enlarged cross sectional view taken on line 2—2 of FIG. 1 through one of the abrasive segments and a portion of the center to show the construction and tapered means for locating and retaining the segment to the center including a mating single tapered segment locating hole in both the segment support member and one side flange portion of the center and a tapered segment locating and retaining member screw threaded into the opposite side flange portion;

FIG. 3 is an enlarged side view of one of the composite abrasive segments shown in FIG. 1 mounted on the center; and

FIG. 4 is an enlarged cross sectional view showing a modified form of the tapered means for locating and retaining the segments to the center including a double tapered locating hole in and providing the segment support member with an opposite internal tapered mating surface at each side of the locating hole;

FIG. 5 is an enlarged cross sectional view of another modified form of the means for locating and retaining the segments including a straight non tapered locating hole in the segment support member engaged by a portion of a tapered locating member at one side of the hole;

FIG. 6 is an enlarged cross sectional view of another modified form of the means for locating and retaining the segments wherein the center has an opposite tapered hole in each of the opposing side flange portions in mating engagement with a tapered locating nut and a tapered member threaded therein engaging opposite sides of a segment support member within straight non tapering locating holes therein; and

FIG. 7 is an enlarged cross sectional view of still another modified form of the means for locating and retaining the segments, wherein the center has an opposite tapered hole in each of the opposed side flanges in mating engagement with a tapered locating nut and a tapered member threaded therein engaging opposite tapered surfaces of a segment support member with a double tapered locating hole therein.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIGS. 1 and 2, there is shown a segmental cut-off grinding wheel 10 of relatively large diameter which may be anywhere between 2 to 6 feet and have an axial thickness of between one-fourth to three-fourths of an inch. The wheel 10 comprises, a thin rotatable reusable drive cylinder, center, disc or hub 12 with suitable means, such as, a center hole 12*a* for mounting the wheel 10 on a suitable rotatably drive spindle or arbor of a cut-off machine. As shown, the reusable drive center 12 is generally of circular shape and has opposite sides or surfaces 12*b* and 12*c* extending radially outward from the center hole 12*a*, about the axis of the center, to a peripheral or circumferential surface 12*d* of the center. Extending radially inward from the peripheral surface 12*d* is a narrow annular segment aligning groove 12*e* of predetermined substantially uniform axial width or thickness of between 0.050 – 0.125 of an inch located between and at substantially equal distances from the opposite sides 12*b* and 12*c*. The narrow aligning groove 12 *e* extends continuously around the center a predetermined substantially uniform radial depth of between 1 – 3 inches to a substantially circular surface 12*h*, of predetermined diameter and radius, at the bottom of the groove which separates and provides a pair of axially spaced opposed side flange portions 12*f* and 12*g* on the center. Preferably the center is a steel disc which has been pretensioned in the conventional way as by peening or working the metal in any suitable way to stiffen and increase its rigidity.

Through the side flange portions 12*f* and 12*g* are a plurality of equally spaced identical groups of axially aligned fastening means or threaded apertures 12*i* and tapered apertures and internal tapered surface 12*j* in mating engagement with tapered segment locating and retaining members 14 therein of substantially identical size and shpape with the axes of each group of members 14 identically or equally spaced on the same base circle *bc* of greater radius and diameter than the circular surface 12*h*.

Each of the segment locating and retaining members 14 has an axial length no greater than the thickness of the center 12 and a tapered or cone shaped segment locating surface or portion 14*a* at one end extending axially from a large end or diameter of the taper to a smaller end or diameter of the taper adjacent a threaded end portion 14*b* screwed into the threaded aperture or threaded surface 12*i* in the opposite flange portion 12*f*. There is a slot provided in the tapered portion 14*a* for turning the member 14 with a conventional screw driver. However, the slot can be one to accomodate an allen wrench or any other suitable or conventional drive tool.

Mounted on, equally spaced around and secured to the reusable hub or drive center 12 are a plurality of identical interchangeable, replaceable and detachable composite reinforced resin bonded abrasive segments 30. Each composite segment 30 comprises, a thin segment support member, base member or shoe 32 with an outer or upper radial portion 32*a* embedded in, interlocked with and resin bonded to the lower central radial portion of an abrasive portion, member or element 34. At least one layer of reinforcing material 36, such as, fiber glass cloth is resin bonded to a side of the support member 32 and extends radially through the abrasive portion 34 bonded thereto, to the outer circular peripheral or circumferential surface of the composite segments 30 and grinding wheel 10. The segment support member 32 may be either a one piece or a composite laminated structure of suitable high strength material, for example, metal, plastic, reinforced plastic, and fiber glass.

Preferably the segment support member 32, as shown in FIG. 2 and 3, is an arcuate or fan shape piece of metal, such as, steel but may be a laminated structure made of resin bonded layers of either open or closed mesh fiber glass cloth or fiber glass woven roving as disclosed in the above mentioned copending application to which reference may be had for details not disclosed herein. Preferably the metal segment support member 32 has in its upper portion 32*a* means for interlocking the abrasive portion or member 34 thereto comprising a plurality of apertures or holes 32*b* through which the resin bonded abrasive material extends and interconnects opposite sides of the abrasive member 34,

Projecting radially inward from the concave side, under side, or inner side and smallest radius of the arcuate abrasive portion 34 is a lower segment mounting portion or tongue portion 32*c* of the segment support member 32. The tongue or mounting portion 32*c* extends into the space, groove or slot 12*e* formed between the opposing inner surfaces or sides of the flange portions 12*f* and 12*g* and has a group or plurality of spaced single chambered, beveled or tapered segment locating holes or apertures and internal chamfered, beveled, or tapered surfaces 32*d* of smaller size or diameter than the tapered apertures and internal tapered surfaces 12*j*. The tapered holes 32*d* and their centers or axes are spaced substantially the same as the tapered holes or aperatures 12*j* and substantially equal distances from the opposite radial end surfaces of the tongue portion on the same base circle *bc* on which the equally spaced groups of the tapered apertures 12*j* are situated.

If desired, compressed resilient means may be provided between the abrasive surface and the center for placing the segment support member **32** in tension, and/or compensating for variations in the contour, and/or the corner radius of the inner surface of the abrasive portion **34.** Preferably the compressible resilient means comprises a plurality of narrow strips **16** of, for example, conventional resilient plastic or rubber material, initially of greater thickness than and compressed in the space between the abrasive portion and the peripheral or circumferential surface of the center.

Forcing and displacing the abrasive segments **30** inwardly sufficiently to align the tapered aperatures **12***j* and **32***d* and inserting the tapered locating and retaining members **14** compresses and preloads the resilient material **16** which pretensions the segment support member **32,** conforms to and fills the space between the adjacent surfaces of the abrasive portions and periphery of the center sufficiently to help the segments resist any side bending forces or reverse stress applied to them during grinding.

Alternatively, more or less than the number of the tapered segment locating and retaining members **14** shown can be used to attach an abrasive segment and the geometrical shape, and included angle A of the tapered portion **14***a* of the members **14** and the mating tapered holes **12***j* and **32***b* can be varied. Angle A is preferably about 30° but may be from 10° to 60°.

Abrasive portion **34** of the segment **30** can be made by molding it to the desired shape or preforming and bonding together suitable layers of an abrasive mix or mixture containing at least abrasive particles and resinoid bonding material, such as a conventional thermosetting phenolic resin. The abrasive particles may be natural or synthetic diamond, metal oxide, and carbide materials such as alumina, alumina-zirconia, silicon carbide, boron carbide, tungsten carbide, and mixtures thereof.

The composite segment **30** can be made in various ways but the preferred method is to simultaneously mold and bond the abrasive mix, the layer or layers of reinforcing material **36,** and the upper portion **32***a* of the segment base member **32** together to the desired size and shape determined by a mold. For example, a typical conventional mold may have a mold cavity of the desired arcuate shape, depth and thickness to produce the abrasive portion **34** and means to position and support the segment base member **32** therein so the outer radial portion **32***a* projects into the cavity. First an outer layer of the abrasive mix of the predetermining depth to form an outer side portion of the abrasive portion **34** is spread upon the bottom of the mold cavity. If two, pieces of reinforcement **36** are desired, one preformed piece of reinforcing material cut-out of a sheet of Lewcott 955 open mesh fiber glass cloth precoated with like phenolic resinoid bonding material commercially available from Lewcott Chemical and Plastic Corp., Millbury, Massachusetts is laid on the loose layer of mix. Then a preformed segment base member **32** is placed in the mold so that it extends into the cavity and over the reinforcing material the desired amount. More of the abrasive mix is spread to fill the space and form the central or inner layer between the outer edge of the segment base member and the mold wall and the interlocking holes **32***b* if present. Thereafter, either a final outer layer of abrasive mix is spread thereover or a second piece of preformed reinforcing glass cloth **36** is first laid over the central or inner layer and a side of portion **32***a* followed by spreading a final outer layer of the abrasive mix thereover. The mold cavity is then closed with a suitable mold pressing plate and the mold placed between heatable platens of a conventional hot press, where the abrasive mix, including the resin bond, the reinforcement and the segment support member are hot pressed and resin bonded into a unitary composite segment of the desired size and shape at a pressure of one-half to *l* ton p.s.i. and temperature of 165° C for 15 minutes. The hot pressed composite segment is then stripped or removed from the mold and placed in an oven for a predetermined period of time at a predetermined temperature to thoroughly cure the thermosetting resin bond.

Alternatively, the abrasive segment **30** may have laminated fiber glass segment support members **32** and made by either hot or cold pressing the components together and curing the resin in the manner disclosed in the above mentioned copending application to which reference may be had for details not disclosed herein.

After the molded segment is cured it is placed in a suitable precision drill jig or fixture for locating and drilling the segment locating holes and internal surfaces **32***d.*

The abrasive segment **30** may have as shown in FIG. **4,** double chamfered, beveled or tapered segment locating holes or apertures and internal chamfered, beveled or tapered surfaces **32***g* instead of the single chamfered, beveled, or tapered locating holes and internal chambered, beveled or tapered surfaces **32***d* shown in FIG. **2.** The double tapered holes provide an identical internal tapered or cone shape locating surface **32***g*, at each side of the segment, relatively narrow width for engagement with the tapered portion **14***a* of a tapered segment locating and retaining member **14.** Each internal tapered surface **32***g* may have an axial width or length less than but no greater than one-half the axial thickness of the tongue **32***c* of the segment support member **32.** The large diameter, at each opposite end of the double tapered aperture and side of the tongue **32***c* are identical and the degree of taper or angle of the tapered surfaces therein at each end of the hole are identical in number from the axis of the hole **32***g*. However, the tapered surfaces **32***g* extend axially in opposite directions, diverging from the inner smaller diameter to the larger diameters and converging from the larger diameters at the sides to the smaller diameter between the sides of the tongue portion and ends of the locating hole **32***g*.

In another embodiment shown in FIG. **5** the tongue portion **32***c* of the abrasive segment **30** has non-tapered or straight segment locating apertures and internal surfaces **32***h* of a diameter substantially equal to the smaller diameter at the inner side of the flange portion, of the tapered hole **12***j* in the flange portion **12***g*. The tapered or truncated cone shape portion **14***a* of the segment locating and retaining member **14** makes substantially circular line contact with, aligns and centers the internal circular surface of the segment base member at the end of the hole **32***h*. It can be obviously seen in both of the embodiments shown in FIGS. **4** and **5** that the double tapered holes **32***g* and the straight holes **32***h* allow the abrasive segment to be turned end for end reversed because they make the segment base member symmetrical about a central plane. Thus, interchangeable abrasive segment **30** with two reinforcing members thereon are likewise symmetrical about the central plane and can be installed without the need to reverse the segments while interchangeable abrasive segments **30** with asymmetrical abrasive portions and one reinforcing member **36** therein can be easily reversed to place one or more of the non-abrasive reinforcing members **36** in two different rotational grinding planes, one adjacent each of the opposite sides of the wheel. Preferably every other of the reversible segments **30** with but one reinforcing member **36** are reversed and assembled so that the reinforcement **36** of adjacent segments are staggered and alternately shifted from adjacent one side to a position adjacent the other side of the wheel.

Other embodiments of the invention are shown in FIGS. **6** and **7** wherein the center **12** has a double tapered hole comprising the tapered hole and tapered internal surface **12***j* in the flange portion **12***g* and an opposite tapered aperture or hole and tapered internal surface **12***k*, not necessarily, but preferably of identical size, shape, and degree of taper in the opposite flange portion **12***f* as the hole or surface **12***j*. The tapered portion **14***a* of segment locating and retaining member **14** forcefully engages and is centered by the internal tapered surface or hole **12***j* when the threaded portion **14***b* is threaded into a tapered slotted nut **18** with an outer tapered surface forced into mating engagement with and centered by the internal tapered surface **12***k* within the tapered hole. Thus, the tapered nut **18** with a threaded hole therein together with the engaging tapered internal surface **12***k* provide means for fastening the end portion **14***b* thereto and the tapered segment locating and retaining member **14** to the center. Also, the identical tapered nut **18** together with the tapered member **14** provide a composite segment locating and retaining or fastening means which can be reversed to engage either of the tapered holes and surfaces **12***j* and **12***k* and either both of the opposite end surfaces or edges of a straight segment locating hole **32***h* as shown in FIG. **6** or both of the opposite tapered surfaces of a double tapered hole **32***g* in the tongue portion **32***e* of the segment support member **32** as shown in FIG. **7**. If desired the threaded end of the members **14** may be staked to or adhesively fixed to the center **12** or to the nut **18** in any suitable manner to prevent loosening; but, not forceful removable thereof from the center **12** or nut **18**.

In addition to precisely locating and retaining the abrasive segments on the center, the tapered segment locating and retaining or fastening means also serve to positively hold the side flange portions **12***g* and **12***f* together against the segment support member and prevent them from spreading apart, whereby the segment support member **32** is clamped between the flanges **12***g* and **12***f*.

A typical new segmental cut-off wheel constructed according to the invention may comprise by example only, identical arcuate composite abrasive segments **30** with steel segment base members embedded approximately 1 inch into the abrasive portions **34** made to precise dimensions necessary to make them interchangeable. Each new abrasive portion **34** would initially have an outer or convex peripheral surface with a radius of 15-½ inches, an inner or cancave abrasive surface with a radius of 11-½ inches at the shoulders overhanging the opposite sides of the metal segment support member **32** with an inner concave surface approximately 9-9/16 inches in radius. The abrasive section **34** being 0.250 of an inch in axial thickness by 4 inches in radial width or depth and provide 3 inches of usable abrasive before replacing, the steel tongue portion **32***c* 0.050 of an inch thick by approximately 1-15/16 inches in radial depth with the abrasive section **34** overhanging the sides of the tongue portion equally, approximately 0.100 of an inch and have an included angle of approximately 35° between the opposite radial end surfaces or edges of the segment.

Excess cured thermosetting phenolic resin flash or material is removed and the precisely formed composite segment is then placed and clamped in a drill jig. A group of five identical segment tapered locating aperatures **32***d* are drilled in the segment member **32** with an included angle A of 30° 18 minutes 26 seconds between diametrically opposite internal tapered surfaces **32***d* of the segment member **32** therein and a large diameter of 0.375 of an inch at the large and of the tapered hole **32***d*. The holes **32***d* are equally spaced 1.1025 of an inch between centers measured on a chord of a 6° arc of a base circle *bc* with a radius of 10-½ inches (21 inches in diameter) with the axes of the end holes equal distances from the radial end surfaces or edges of the segment and a chordal distance of 1 inch from each of a pair of radial planes spaced 36° apart and passing between adjacent segments **30** of the grinding wheel **10**.

The composite segments **30** are preferably of shorter arcuate length than the length of an arc of identical radius extending between each pair of radial planes spaced at predetermined equal angles of 36° around the axis of the hub **12**. Thus when mounted on the hub **12** the segments **30** with a maximum radius of 15-½ inches will be spaced from one another and have a space in this specific embodiment of about 0.249 or one-fourth of an inch.

Ten of the interchangeable composite abrasive segments **30** of the dimensions given above are then mounted on a one piece reusable steel drive center with the following approximate dimensions outside diameter of 22-15/16 inches; axial thickness of approximately 0.220 of an inch; a center hole of 4 inches in diameter; a central segment aligning groove 0.051 wide by 1-31/32 inches in radial depth between opposed side flange portions approximately 0.085 of an inch thick and a circular surface with a 9-½ inch radius and 19 inches in diameter at bottom of the annular groove.

Precisely situated with their axes aligned on the same base circle bc with a radius of 10.500 inches and 21 inches in diameter and precision drilled or machined in the side flange portion of the center are 50 5/16-18 pitch threaded holes axially aligned with 50 tapered apertures separated into 10 equally spaced identical groups of five each. Each tapered aperture has diametrically opposite precision tapered surfaces of the center therein with an included angle of 30° 18 minutes 26 seconds between them and an angle of 15°9 minutes 13 seconds from the axis of the tapered aperture. The larger end diameter of each of the tapered aperatures and tapered surfaces **12***j* is 0.421 of an inch measured at the outer side or surface of one of the side flange portions of the center from which the diametrically opposite tapered surfaces converge at a standard rate of 6-½ inches of taper per foot toward one another to a smaller hole or end diameter of 0.375 of an inch, measured at the inner surface of the flange portion within the groove **12***e*. The large end diameter of 0.375 of an inch of the tapered hole and internal taper surfaces **32*d*** measured on one side of the segment support member **32** being equal to, axially aligned with and situated adjacent the 0.375 of an inch smaller end diameter of the tapered aperature **12*j*** at the inner surface of the flange portion **12*g***.

During assembly a one-sixteenth of an inch thick by three thirty-seconds of an inch wide strip **16** of resilient rubber material is compressed to one thirty-second of an inch in between each of the opposite abrasive shoulders or surfaces of the abrasive portion on opposite sides of the support member **32** of each composite segment **30** and the adjacent convex peripheral surfaces **12*d*** of the center. three thirty-seconds

Upon inserting each segment support member **32** in the groove **12*e***, compressing the resilient strip **16** and aligning the tapered holes **12*j*** and **32*d*** a tapered segment locating and retaining screw **14** is threaded into each of the threaded holes **12*i*** in the opposite flange portion. Each of the tapered segment locating and retaining screws **14** move axially into mating engagement with and align the tapered surfaces within the tapered locating holes **12*j*** and **32*d*** which are axially aligned and thereby locating and retaining the composite segment **30** in a precise position on the center. In this example the tapered segment locating and retaining member **14** is approximately seven hirty-seconds of an inch long, has a threaded straight end portion with 5/16-18 pitch screw threads thereon extending axially three thirty-seconds of an inch to or from the small end diameter of a tapered portion **14*a*** with an included angle of 30°18 minutes 26 seconds between diametrically opposite portions of the tapered surface thereon and an angle of 15° 9 minutes 13 seconds from its axis. The tapered portion has an axial length of approximately one-eighth of an inch and tapers at the rate of 6-½ inches per foot from a smaller diameter of 0.354 of an inch adjacent the threaded portion to a larger diameter of 0.421 of an inch at the opposite end with a screw driver slot therein.

Thus, the assembled composite abrasive segments **30** on the hub of the dimensions described above, by example only, produce a segmental cut-off grinding wheel with an outside diameter of **31** inches, ten equally spaced abrasive segments 0.250 thick with sides lying in a single plane about and normal to its axis of rotation and with a center hole 4 inches in diameter.

When the segments **30** have but one reinforcing member **36**, the segments are made and/or assembled so that the reinforcing members **36** of adjacent segments are staggered and alternately shifted from a position adjacent one side of the wheel to a position adjacent the opposite side. Hence all the reinforcement, does not lie in a single non abrading plane but is interrupted by at least one but preferably by a plurality of abrading portions of adjacent segments. Obviously this can be done in various ways, for example, by drilling the tapered locating holes **32*d*** from opposite sides of the segment base member **32** in one-half the total number of abrasive segments **30** on the wheel **10** or drilling one-half of the equally spaced identical groups of the tapered and threaded holes **12*j*** and **12*i*** into the opposite side flange portions **12*f*** and **12*g*** respectively of the center **12**, or make the locating holes **32*d*** straight or double tapered as disclosed above and shown in FIGS. **4** and **5**.

Obviously, larger segmental cut-off wheels than the specific example of the invention given above can be made by modifying the dimensions of the segments and the hub to accomodate greater number of composite segments required to complete the wheel of greater diameter and circumference. Also, the number, size diameter, and angle of the tapered segment locating and retaining members may be varied so long as there is sufficient strength in the total cross sectional area thereof to effectively oppose the calculated centrifugal load for force exerted by each abrasive portion **34** bonded to the segment base member **32** during rotation at the desired predetermined speed and surface feet per minute. By increasing their cross sectional area and/or strength the number of segment locating and retaining members required can be reduced which would obviously change the spacing of each group of the holes **12*i*** and **12*j*** in the center.

Although the invention has been illustrated and described in specific embodiments, it is to be understood that many variations of and changes may be made therein without departing from the invention set forth in the following claims.

I claim:

1. A relatively large segmental cut-off grinding wheel comprising:

a relatively large, thin circular reusable drive center rotatable about its axis having

a peripheral surface of predetermined diameter, opposite sides extending to the peripheral surface, a narrow segment aligning groove of predetermined axial width extending inwardly from the peripheral surface a predetermined radial depth between opposing inner sides of opposed spaced side flange portions of substantially equal thickness, a plurality of tapered apertures and internal tapered surfaces therein extending axially through one of the opposed spaced side flange portions and each of the tapered apertures and tapered internal surfaces tapering from a large diameter at one of the opposite sides of the center to a smaller diameter at an inner side of the one side flange portion with axes of the apertures situated and spaced on a base circle of predetermined radius from the axis, and fastening means, in an opposite one of the opposed spaced side flange portions axially aligned with each of the tapered apertures, for attaching a plurality of segment locating and retaining members to the center;

a plurality of identical, interchangeable, detachable and replaceable composite resin bonded reinforced abrasive segments spaced circumferentially around and attached to the center, each having an arcuate abrasive portion adjacent the peripheral surface of greater axial thickness than the center,

a segment support member having

an outer radial portion embedded in, interlocked with, and resin bonded to an inner radial portion of the abrasive portion, a tongue portion with an axial thickness between opposite sides thereof slightly less than the axial width of the aligning groove extending radially inward from the abrasive portion into the narrow aligning groove and situated at substantially equal distances from opposite sides of the abrasive portion and the center, and a plurality of segment locating apertures in the tongue portion each having an end diameter on at least one side thereof axially aligned with and of substantially the same diameter as the smaller diameter of the tapered apertures at the inner side of the one side flange portion; and

a plurality of tapered segment locating and retaining members within the tapered apertures in the one side flange portion, each having

a tapered portion in mating engagement with the tapered internal surface within the tapered aperture and extending axially from a large diameter through the smaller diameter at the inner side into the locating aperature beyond the end diameter and engagement with the segment support member, and

an end portion extending axially from the tapered portion, adapted for engagement with and fastened to the fastening means in the opposite side flange portion.

2. A segmental cut-off wheel according to claim **1** wherein the tongue portion of each of the segment support members have

a plurality of single tapered apertures and internal tapered surfaces therein each in mating engagement with the tapered portion of the segment locating and retaining members and tapering from an end diameter, on at least one side of the segment support member, substantially equal to the smaller diameter at the inner side, to a relatively smaller diameter at an opposite side of the segment support member.

3. As segmental cut-off wheel according to claim **1** wherein the tongue portion of each of the segment support members have

a plurality of double tapered apertures and internal tapered surfaces therein situated at opposite end portions of each of the double tapered apertures, each of the tapered surfaces adapted for mating engagement with but only one of which engages the tapered portion of the segment locating and retaining member and tapering in opposite directions from an end diameter, at each opposite end of the double tapered aperture and side of the segment support member, substantially equal to the smaller diameter at the inner side, toward one another, to a relatively smaller diameter between the opposite sides of the segment support member.

4. A segmental cut-off wheel according to claim **1** wherein the tongue portion of each of the segment support members have

a plurality of straight segment locating apertures and straight internal surfaces therein with an end diameter at each opposite end of each of the straight apertures and sides of the segment support member substantially equal to the small diameter at the inner side and with the tapered portion of the segment locating and retaining member therein engaging the segment support member at one end of the straight internal surface at one end of the straight segment locating aperture.

5. A segmental cut-off wheel according to claim **2** wherein the fastening means in the opposite side flange portion comprises:

a plurality of threaded apertures axially aligned with the tapered apertures in the one side flange portion,

and wherein the segment locating and retaining members have threaded end portions threaded into the threaded apertures.

6. A segmental cut-off wheel according to claim **3** wherein the fastening means in the opposite side flange portion comprises:

a plurality of threaded apertures axially aligned with the tapered apertures in the one side flange portion,

and wherein the segment locating and retaining members have threaded end portions threaded into the threaded apertures.

7. A segmental cut-off wheel according to claim **4** wherein the fastening means in the opposite side flange portion comprises:

a plurality of threaded apertures axially aligned with the tapered apertures in the one side flange portion,

and wherein the segment locating and retaining members have threaded end portions threaded into the threaded apertures.

8. A segmental cut-off wheel according to claim **3** wherein the fastening means in the opposite one of the opposed side flanges comprises;

a plurality of opposite tapered apertures and opposite tapered internal surfaces extending axially through the opposite one of the opposed spaced side flange portions in axial alignement with the tapered apertures in the one spaced side flange portion and tapering from a second large diameter on an opposite side of the center to a second smaller diameter on an opposite inner side of the opposite side flange portion of the center substantially equal to the first mentioned smaller diameter on the inner side of the one side flange portion; a plurality of tapered nuts in the opposite tapered apertures each having

a threaded aperture into which the end portion of the segment locating and retaining member is threaded,

an outer tapered surface in mating engagement with the opposite tapered internal surface within the opposite tapered aperature and extending axially from a large diameter through the second smaller diameter at the opposite inner side into and beyond the opposite end diameter of the double tapered segment locating aperture and mating engagement with the opposite tapered internal surface of the segment support member.

9. A segmental cut-off wheel according to claim **4** wherein the fastening means in the opposite one of the opposed side flanges comprises:

a plurality of opposite tapered apertures and opposite tapered internal surfaces extending axially through the opposite one of the opposed spaced side flange portions in axial alignment with the tapered apertures in the one spaced side flange portions and tapering from a second large diameter on an opposite side of the center to a second smaller diameter, on an opposite inner side of the opposite side flange portion of the center substantially equal to the first mentioned smaller diameter on the inner side of the one side flange portion;

a plurality of tapered nuts in the opposite tapered apertures each having

a threaded aperture into which the end portion of the segment locating and retaining member is threaded, an outer tapered surface in mating engagement with the opposite tapered internal surface within the opposite tapered aperture and extending axially from a large diameter through the second smaller diameter at the opposite inner side into and beyond the opposite end diameter of the straight segment locating aperture and engagement with the opposite end of the straight internal surface of the segment support member.

10. A segmental cut-off grinding wheel according to claim **5** further comprising

a strip of resilient material compressed between the peripheral surface of the center and inner surface of the arcuate abrasive portion adjacent each side of the segment support member of each composite abrasive segment.

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