April 28, 1959 A. S. TITCOMB 2,883,807

SEGMENTAL BONDED ABRASIVE BODIES

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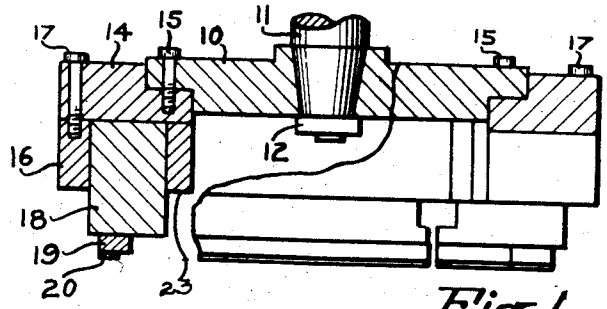

Fig. 1.

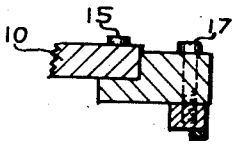

Fig. 8.

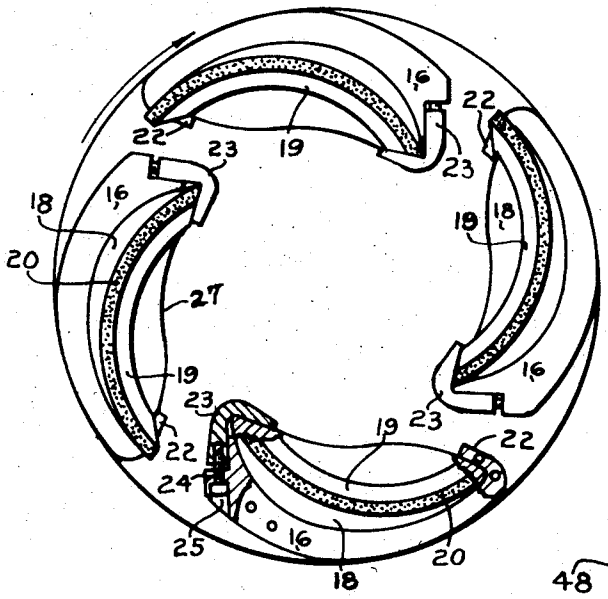

Fig. 2.

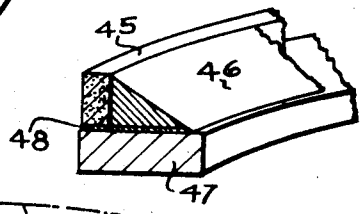

Fig. 6.

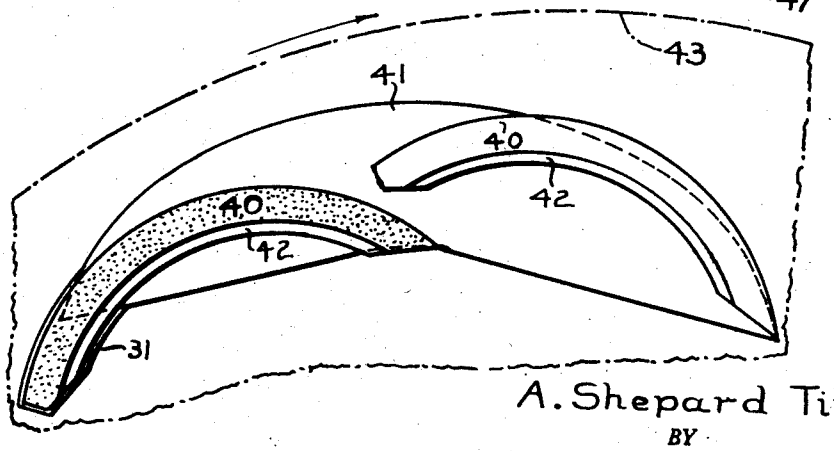

Fig. 7.

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Fig. 3.

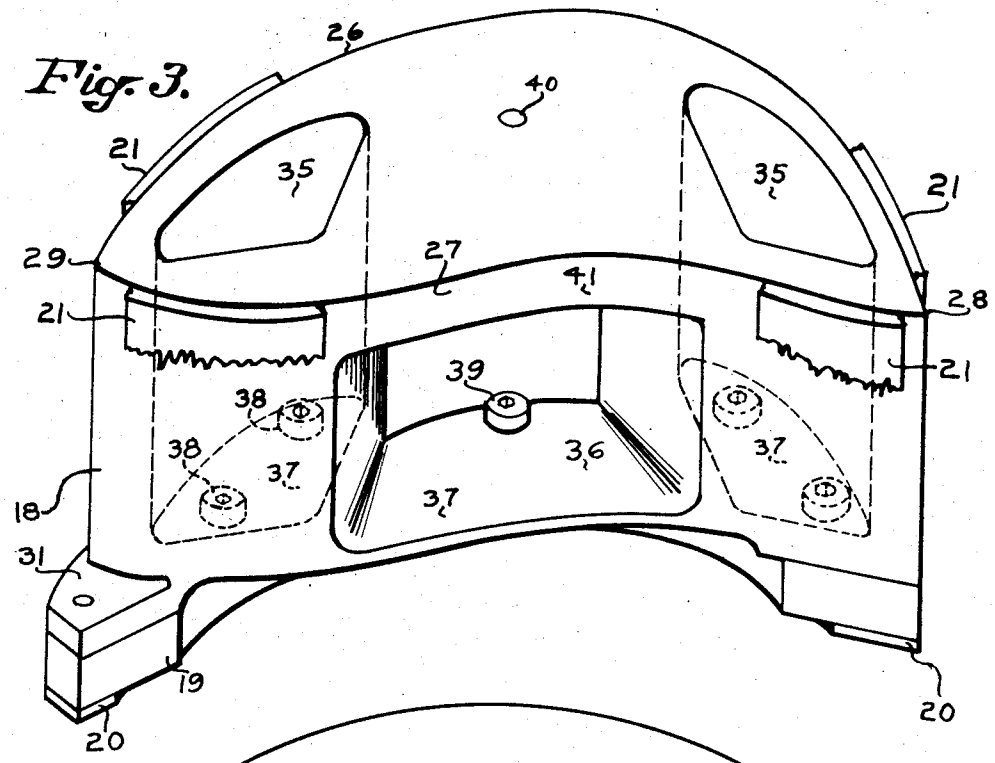
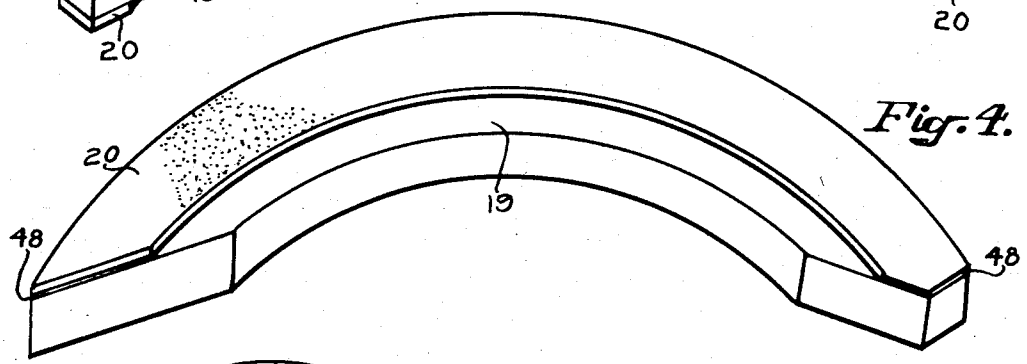


Fig. 4.



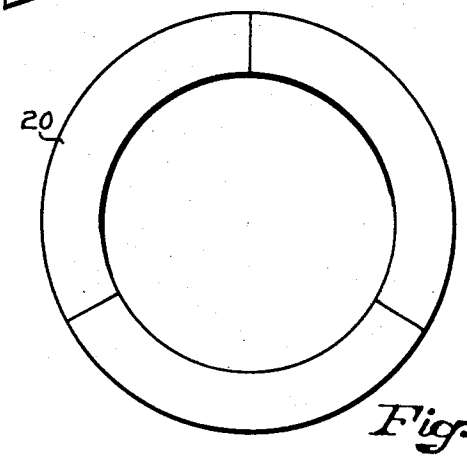


Fig. 5.

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SEGMENTAL BONDED ABRASIVE BODIES

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Application September 18, 1956, Serial No. 610,593

7 Claims. (Cl. 51—209)

This invention relates to segmental abrasive articles, and more particularly to abrasive segments and wheels formed thereof which have diamond or other fast cutting abrasive grains as the primary abrading constituent.

Abrasive diamond grains are highly superior for various types of grinding, and they have been customarily incorporated in many shapes of grinding wheels. For some purposes, a wheel is shaped as a ring or hollow cylinder with the abrasive exposed on the plane surface at one end of the cylinder. The rim of such a wheel is usually wide, and often as wide as one inch for a twelve inch diameter wheel, to give the required strength, so that there is a very large area of continuous contact between the wheel and the work. If diamond abrasive is used on such a ring-shaped wheel, and a work piece is passed across the wheel face, it is found that the large area of contact causes the generation of an excessive amount of undesirable heat due to the large amount of non-cutting bond that is rubbing across the work, and particularly after the abrasive surface has become loaded with detritus and diamonds have become dislodged.

One object of my invention is to reduce this undesired heating condition and to provide a more efficient cutting action. This is accomplished in part by so arranging, through shaping and placing, the bonded diamond abrasive body that it has momentarily only a small area of contact with a given portion of the work.

A further object is to provide this efficient and costly abrasive material as readily replaceable or renewable segmental members of such shapes and dimensions that a large proportion or all of the diamond grains may be used before replenishment is required.

There are various types of rotary chucks in which abrasive segments are mounted, such as are shown in my prior Patents #2,476,334, 2,541,844 and 2,700,853. The standard abrasive segment is a massive body of bonded abrasive grains and is mounted in clamping jaws, or otherwise secured in position. Diamond abrasive should be employed as a thin layer or strip and not as a solid or massive body of the bonded abrasive material. Also, for certain purposes a discontinuity of abrasive action is preferred.

Hence, a further object is to so shape, place and space a set of bonded diamond strips that they can operate efficiently to remove the detritus and sweep across the work obliquely and more tangentially than radially.

The layer of bonded diamond granules requires a rigid backing support, and particularly where a narrow and thin strip of bonded diamond grains is employed.

A further object is, therefore, to provide a suitable mounting for a bonded diamond abrasive strip which provides the right arrangement and configuration of the abrasive for an efficient cutting action. To this end, I attach the diamond strip securely to a rigid segment which serves as a support and is arranged to be removably mounted on a rotary plate or wheel.

Another object is to removably mount the rigid segment on a shoe, which may be clamped in a standard or suitably shaped chuck, so that the bonded abrasive strip and its backing segment may be directly substituted for a standard abrasive block of the usual bonded crystalline alumina or silicon carbide and employed for a required grinding operation. This object is further satisfied by providing a plurality of duplicate rigid segments with the abrasive strips cemented thereon and arranging them as required on shoes which are in turn readily mounted in the supporting chuck.

A further object is to so shape and mount a bonded abrasive strip as to provide a required side cutting and plow-like action which insures that the abrasive grains will sweep across a work face as the strip is revolved and the detritus will be forced outwardly and away from the path of revolution of the strip, thus decreasing the loading of the abrasive and improving the cutting action.

A general object of the invention is to provide duplicate segments with bonded abrasive strips secured thereto, in which the strips are so shaped and arranged that the segments may be removably replaced on chuck carried shoes, and thus substitute and employ varying specifications of size and concentration of grains and of bond so as to carry on different types of grinding operations. This requires only a standard chuck structure as well as a set of shoes shaped to interfit with the chuck clamps so that the only replaceable element is that of the segment with its bonded diamond strip secured thereto. Thus different shapes of abrasive strips and different specifications of grain sizes and concentrations and variations in their bonded structure may be employed with the same type of shoe and supporting chuck.

I have further found that the narrow abrasive strip may be arranged at a desired angle to the direction of rotary travel, i.e., a circle concentric with the wheel axis, so that the cutting action is accomplished primarily by the line of diamond grains at the forward edge. Also, if the leading end or nose of the strip is somewhat nearer the wheel center than is the trailing end, and if the forward side edge is more tangential than radial, this provides a sweeping action in which the strip passes progressively across the work face and serves to thrust the debris outwardly and away from any further contact with the work.

Hence, another object is to provide various sizes and shapes of an elongated narrow and arcuate strip of bonded diamond grains in which the arcuate shape is predetermined for a given grinding operation, and to so arrange and mount the arcuate strip on a segment at a predetermined angle relative to the circumferential line of travel that the cutting action may be selected for different types of work to be ground. Other objects will be apparent in the following disclosure.

In order that these various features of my invention may be more readily understood, reference is to be had to the accompanying drawings which illustrate a preferred embodiment of the invention and in which:

Fig. 1 is a sectional view of a face plate on a grinding machine spindle carrying a chuck mounting plate with clamp bodies attached thereto which carry shoes on which the abrading segments are removably mounted;

Fig. 2 is a plan view of the under side of a chuck mounting plate with clamp bodies mounted thereon and carrying shoes on which the abrading segments are secured;

Fig. 3 is a perspective view of a shoe having a metal segment carrying a diamond abrasive strip secured thereto;

Fig. 4 is a perspective view of the metal segment of Fig. 3 to which a diamond abrasive strip is cemented;

Fig. 5 is a diagrammatic showing of the formation of three 120° diamond strips made from a standard 360° circular mold;

Fig. 6 is a fragmentary perspective view, cut away, showing how a diamond strip is mounted and supported on a segment when the wall thickness or height of the strip perpendicular to the plane of abrasion is large as compared with its width;

Fig. 7 is a fragmentary plan of two diamond strips mounted on a single segment; and

Fig. 8 is a fragmentary sectional view showing the abrasive strip and its backing segment detachably secured directly on a rotary plate.

In accordance with one phase of my invention, I have provided a shoe of suitable material, and particularly metal, which is shaped to fit in the clamps of a rotary chuck as a replacement for the standard bonded abrasive block heretofore employed. This shoe has removably attached to it a segment, made preferably of metal, and that segment carries the strip of bonded abrasive material rigidly secured in place, as by means of a cement. The segment is shaped relative to the under face of the shoe so that it may be removably fastened thereto, as by cap screws. Various shapes of abrasive strip may be mounted on the segment to provide the required abrading action. It is preferred that the segments be of standardized shape so that they may be replaceably mounted on a shoe, and thus many types of chucks may be used with shoes to interfit therewith and on which the standardized segments and strips may be interchangeably mounted.

One type of a chuck mounting for such a shoe is illustrated in Figs. 1 and 2. As shown, a rotatable face plate **10** has a central keyed tapered bearing and is removably secured to the matching coned end of the spindle **11**, either vertical, horizontal or in other angular arrangement, as by means of suitable nuts **12** on the spindle engaging the under side of the plate. The face plate **10** may be under cut or have a step formation, known as a pilot, on its under side and be so shaped that a suitable chuck mounting plate **14** may be removably mounted, as by means of a row of cap screws **15**, to fit securely against the under surface of the face plate. Various constructions may be adopted for the purpose of providing this mount.

As shown in my prior patents, a bonded abrasive segment has been secured to the under face of the plate **14** by a clamp body **16** removably mounted thereon. In accordance with my invention, I replace such an abrasive segment with a shoe **18** of metal or other non-abrasive material so constructed that it will removably fit within the clamp body. This shoe **18** removably carries a segment **19** of metal or other material on which in turn is fixedly mounted a strip **20** of bonded diamond or other abrasive material of such shape and arrangement as to satisfy the abrading requirements. Suitable pads **21**, which may be of gasket material, may be secured at the land positions of the shoe to position the shoe within the clamps and absorb any unevenness of the fit (Fig. 3).

Various types of clamp body may be employed to secure a matching shoe **18** in position. The clamp body **16**, illustrated particularly in Fig. 2, and as more particularly shown in my Patent #2,700,853, is generally arcuate in shape and has a hook shaped rear lip **22** which interfits with one end of the especially shaped shoe **18**. The forward end of the clamp body has an adjustable clamping hook or jaw **23** adapted to fit against the inner front side of the shoe **18** and to be drawn into place to force the shoe snugly into position. This may be caused by means of a screw **24** having its head countersunk in the recess **25** in the clamp body and threaded into a socket in the adjustable jaw **23**, as shown at the lower portion of Fig. 2. The shape of the shoe **18**, which is preferably made of non-magnetic material, such as aluminum or an alloy thereof, is such that with its pads **21** it interfits properly with the clamp hooks **22** and **23**. It will be appreciated that there are many types of chucks and clamps adapted for various shapes and types of abrasive segments, and that the metal shoe **18** may be made of the general shape and dimensions corresponding with the abrasive segments heretofore used in such chucks. Screws **17** attach the clamp body to plate **14**.

A primary feature of my invention pertains to this special shoe adapted to be mounted in a standard or a suitable chuck which carries the diamond abrasive strip on a segment plate attached to the shoe. This shoe **18**, as shown particularly in Fig. 3, may be a casting of aluminum alloy or other non-magnetic material. It has substantially parallel top and bottom faces. Its outer curved surface **26** is shaped to fit substantially against the inner curved surface of the clamp body **16**. Its inner curved face **27** is somewhat S-shaped and intersects the outer face **26** to form a pointed leading nose portion **28** and a trailing end portion **29**. These two end portions are suitably shaped, whether or not pointed, to fit properly within the hooks **22** and **23** of the clamping unit. The shoe may be provided with a rearwardly projecting lug or ledge **31** which lies below the clamps and serves to provide an extension support for the end of the metal segment plate **19** therebeneath, so that the shoe may carry a diamond strip **20** which is longer than the main body of the shoe and so supports the trailing end of the abrasive strip. The segment plate **19** and the shoe have parallel contacting plane faces perpendicular to the axis of rotation which provide a firm support for the segment and its abrasive strip.

The shoe casting is shown in Fig. 3 as provided with three hollow recesses, two being vertical recesses **35** located close to but spaced from the end portions **28** and **29**. The other recess **36** is horizontal and spaced by wall portions from the vertical recesses. Beneath each of the recesses is a floor portion **37** having an under face lying in a plane and arranged for supporting the metal segment **19**. Suitable "Allen" headed cap screws **38** are mounted in the recesses **35** and a cap screw **39** in the recess **36**. These project through the floor portion **37** and have their lower ends threaded into the metal segment **19**. Thus, the segment may be readily replaced by removal of the cap screws. A hole **40** is provided in the upper top plate portion **41** of the shoe which is in alignment with the recessed portion of the head of the cap screw **39** so that a suitable tool may be projected downwardly through the opening **40** for proper manipulation of the screw **39**.

The metal segment and the bonded abrasive strip are made separate from the shoe **18** so that various shapes and arrangements of the strip **20** may be employed for the different abrading operations. The number of shoes employed depends upon the wheel size and the number of clamp sets, the four illustrated in Fig. 2 being normally adapted for a 12" grinding chuck. Three of the segments will serve for 9" and 10" chucks, and five for 14" chucks. If the chuck is larger in diameter, then a larger number of shoes and clamps may be employed. For example, nine segments may be mounted on a chuck of approximately 23.75" in diameter. The diamond strips and their segments are preferably standardized in structure for the various requirements.

The diamond strip has a leading outer edge perpendicular to the plane of abrasion. It is preferably made arcuate and may be so cooperatively arranged on the chuck plate in association with other strips that the sum of the radial angles subtended by each of the strips may exceed 360° and thus gives for a given wheel diameter an optimum leading edge contact. Each diamond strip is a curved segment subtending an angle of 120°, and each strip is mounted on a 120° segment. When four strips with their segments are employed, the abrading action of the assembly is one and one-third times that of a continuous annular strip having the same radius. Since the cutting action is primarily at the forward side edge of the strip, then the use of the several strips in an overlapping arrangement assures an optimum cutting action.

The strip may be only wide enough to have the desired strength and bearing on the work. One purpose of the projecting ledge **31** is to support the extra length of the strip **20** and its segment **19** in the specific arrangement of Fig. 3.

The diamond strip of the type shown in Fig. 4 may be molded in its final shape, or it may be made by initially molding a complete ring of the abrasive and bond and then cutting it into a desired number of segments, such as the three shown in Fig. 5. Also, the metal segment **19** should be similarly made.

The abrasive strip **20** is preferably so shaped and mounted that the leading end of the strip is located inwardly toward the center of revolution relative to the trailing end of the strip and so arranged that the detritus is swept outwardly during the grinding operation. That is, the forward end of the strip has its radial distance from the center of revolution materially less than the radial distance of the rear end. The metal segment **19** is suitably made to provide a backing mount for the abrasive strip, whatever its shape. Also, the diamond strip **20** is preferably given such an arcuate configuration that the leading portion of the outer curved face (Fig. 2) provides a considerable lateral sweeping action across the work and thrusts the detritus outwardly and in such a manner that it clears the path for the following abrasive strip. The outer face of the trailing end of the flat strip **20** illustrated approaches more closely to a circular arc lying in the general direction of rotation of the strip, so that the rear end portion provides a more effective shoulder grind. This abrasive strip may be shaped variously as found expedient for the different types of material to be ground or abraded and within the requirements of mounting on the shoes. However, the shape of the strip is not limited by the clamp shape, since many suitable shapes may be adopted for the strip and the backing segment.

A modification of the construction shown in Fig. 7 has a plurality of abrasive strips **40**, such as two, mounted on a single larger shoe **41** which is shaped to match a clamp body for a series of the larger sized chucks. Each abrasive strip is cemented to a metal segment **42** and the latter is removably fixed on the shoe **41** in a cooperative and spaced arrangement by means of cap screws as above described. As shown, two of the abrasive strips **40** are cemented on their metal segments **42** in an arcuate arrangement, so that when the mounting plate **43**, indicated by the dotted line, is rotated in the direction of the arrow, the leading nose of each strip will be located nearer the radial center of the wheel rotation than is the trailing edge, and thus provide the lateral sweeping outwardly of the detritus. The spacing between the strip **40** provides for the outward movement of this material. Also, the strips may be arranged at any other desired angle in the direction of rotation so as to give a needed abrading action.

If the abrasive strip is to be made thicker, such as when crystalline alumina or silicon carbide as well as diamond is employed, a reinforcement backing may be required. Such a construction is shown in the fragmentary view of Fig. 6 in which the abrasive strip **45** is a comparatively thick body and has a reinforcement **46** engaging its inner curved portion for receiving the lateral thrust of the abrading operation. These two parts, which may be molded as a substantially integral body, may be cemented on the metal segment **47** by means of cement **48**. The reinforcement portion **46** may be tapered as illustrated and is made of a material which is more wearable than the abrasive body **45**, so that it maintains an adequate supporting relationship but does not interfere with the action of the abrasive. This segment **47** may be shaped as shown in Fig. 4 or otherwise as required for an abrading operation, and it is preferably mounted on a clamping shoe as above described.

The bonded abrasive strip **20** or **45** is formed of abrasive grains of a required grit size and a suitable bond, such as a potentially reactive phenolic formaldehyde resin, vulcanized rubber or other bond of standard use. This strip is in turn cemented to the segment **19** or **47**, as by means of a potentially reactive phenolic formaldehyde or other suitable cement.

Many suitable types of bond and methods of manufacture may be employed for the diamond or other abrasive grains selected in accordance with standard practice. For example, the abrasive grains may be mixed with potentially reactive phenolic formaldehyde resin in a powdered form and a suitable amount of a liquid plasticizing agent, such as furfural, may be added to provide a moldable mass. The mass is compacted under heavy pressure in a suitable mold, and heat is applied to the molded article to transform the resin to its ultimate infusible and hard condition. A polymerized resin bond may be formed by condensing in the presence of phosphoric acid a mixture of aniline and melamine with formaldehyde. Such a bond in powdered form may be incorporated with abrasive grains and a suitable plasticizing agent, such as furfural, and the mass is molded in a hot press under high pressure, such as 3 tons per square inch, and heated at 175° C. for a suitable time, such as 90 minutes, to set the bond. The various bonds may also be used in a potentially reactive liquid form, or if desired, mixed with a catalytic agent which expedites the hardening action. Likewise, rubber bonds may be employed, such as a vulcanizable plastic rubber composition in which the abrasive grains and a vulcanizing agent are suitably incorporated, and the mass is then heated to vulcanize the rubber. Various polymerizable resins may be incorporated with the rubber for bonding purposes. Also, the abrasive grains may be first wet with a liquid adhesive, such as the A stage phenolic resin or furfural, and a resinoid or a rubber powder incorporated therewith to provide the required moldable mixture. If desired, a powdered filler, such as ground quartz or another abrasive, such as crystalline alumina or silicon carbide, may be incorporated with the diamond grains for the desired abrading action. If desired, the abrasive grains may be etched or cleaned or otherwise treated to prepare their surfaces for adhesion to the bond. The grit sizes of the abrasive grains ordinarily range from those which will just pass through screens of from about 80 to 320 meshes per linear inch. Many formulas and bonding procedures well known to those skilled in the art may be employed.

The diamond strip may be fixedly mounted on its metal segment by a suitable bond which is compatible with the bond of the strip. For example, I may employ a potentially reactive phenolic formaldehyde resin in the liquid form which may be suitably heated to transform it into the infusible type, and if desired, the metal segment may have its surface adequately roughened or otherwise shaped to provide a firm adhesion of the strip to the segment, as is indicated by the thin cement layer **48** illustrated diagrammatically in Fig. 4.

If a diamond strip is reinforced by a backing, as shown in Fig. 6, the latter may be formed of suitable grit material, such as silicon carbide, which has such grain size and type of bond structure as to provide substantially the same coefficient of expansion for both the bonded diamond strip and the backing strip. That is, the bond in both the abrasive zone and the backing zone, as well as the pore spaces, may each occupy substantially the same volume percentage, so that the shrinkage of the two zones is substantially equal. The abrasive and backing structures may be molded together in a single mold, so that the resin or other bond employed in each portion may be heat set simultaneously. The bond is preferably the same in each of the two parts, such as a potentially reactive resin. Each part is compressed to the same pore volume percentage so that the percentages of bond and of pores in each part are substantially alike.

For certain requirements, the clamps **16** may be omitted

and the abrading units comprising the segment and its abrasive strip may be mounted directly on the rotary mounting plate, as shown in Fig. 8. In that construction, the under side of the rotary plate 10 interfits with an annular recess on the top of the mounting plate 14 and the parts are connected by cap screws 15. The plate 14 has a set of cap screws 17 threaded directly into the segment plates 19 which carry the abrasive strips 20 thereon, as above described. This requires that the under surface of the mounting plate lie in a plane and that the out faces of the segments 19 fit accurately thereagainst. Hence the mounting plate 14 serves as a shoe which has an outer face on which the flat upper face of the segment plate 19 is removably mounted. The holes for the cap screws 17 are so located as to position the abrasive segments so as to give the required plow and lateral sweeping action of the abrasive strips as above described and which may be located as desired to satisfy a given grinding operation.

It will be appreciated that the abrading unit comprising the abrasive strip 20 and its backing segment 19 may be made as a standardized article which may be mounted on various sizes of rotary plate and in required arrangements and numbers of the units. That is, three abrasive units may be used in a small chuck employing three clamps or in larger chucks of various gradations in size to the maximum which requires a large number of the units. Furthermore, the mounting shoe which carries the abrading unit removably attached thereto is to be shaped to fit in any of the standard clamps of the chucks in use, so that once the shoes have been shaped to fit the required chuck clamp, any desired type of abrading unit may be removably attached to that shoe. Thus, a single type of shoe will serve for a given type of chuck to carry all selected abrading units, and the latter may be mounted on the shoe in either single or double alignment or in desired arrangements relative to the path of travel of the abrading strip. The shoes and segments may be accurately ground or shaped to exact thicknesses, and the abrading units will likewise be accurately made so that when the parts are assembled and mounted on the rotary plate with the shoes engaging the chuck plate 14, the abrading strips will each have a firm footing and contact the work in the required plane.

This standardization of shoes and of the elements of the abrading units provides a minimum inventory on the shelves of the factory, the sales distributors and the plant using the same and thus avoids the expense of and the space requirements for maintaining a large stock. Hence, the user may order such units as fit his requirements of grain size, concentration and type of bond, and any units thus furnished will be readily mountable on his shoe or plate. Both the shoes and the segments are permanent, so that only the relatively thin and narrow elongated abrasive strip needs to be replaced, or the abrasive unit of segment and the abrasive strip cemented thereto may be replaced, if desired. Also, this standarization of units provides for a less down-time on the machines employing the same, in that when the abrasive strips become inefficient, the units may be readily and rapidly replaced by new ones. Also, several holes for the mounting screws which attach the segments to the shoe may be prelocated so that the abrading units may be appropriately placed in the wheel circle to provide the chip clearance factor and the abrading operation required in a particular grinding operation. This invention reduces the direct labor costs, often as much as 30%, as well as the abrasive costs. The segment may be adjusted, as by shims, between it and the shoe, to insure that the abrasive strip exactly contacts the work in the required plane. The abrasive unit as thus made provides a more accurate grinding and cooler cutting with less warpage and a smoother finish and a flatter surface over that attained by the standard diamond tools now in use. A narrow elongated abrasive strip, as claimed, is one which is several times longer than its width, so that the abrasion, which is primarily an edge action, involves a continuity of movement of a long edge over the work with a minimum of frictional heat. The arcuate shape provides a curved outer abrading edge, and the angular arrangement of that edge in a more nearly tangential than radial relation to the rotary path of the strip provides a plow-like action and a lateral sweeping of the detritus away from the abrading zone so as to minimize scratching of the work thereby. Various other advantages will be readily apparent to one skilled in the art.

I claim:

1. In a segmental abrasive chuck including a rotary plate and a set of adjustable clamps arranged on the plate for removably mounting abrasive bodies thereon, a set of abrasive bodies comprising duplicate non-abrasive shoes having lateral clamping faces shaped for interfitting laterally with and being removably mounted in the clamps with their outer faces exposed, a plurality of abrasive units removably mounted on the shoes, each unit comprising a segment plate having a face shaped to mate with and be mounted on any of said outer shoe faces and a narrow elongated element of bonded abrasive grains integral with and fully supported by the plate, and fasteners for removably attaching the plates to the shoe faces and holding the strips with the leading portions of their lateral abrading edges arranged more nearly tangential than radial to the path of revolution.

2. In a segmental abrasive chuck including a rotary plate and a set of adjustable pairs of clamps arranged for removably mounting abrasive bodies thereon, a set of abrasive bodies comprising duplicate non-abrasive shoes having clamping faces shaped for interfitting laterally with and removable mounted in the clamps with their outer faces exposed, a plurality of abrasive units shaped for removably mounting on the shoes, each unit comprising a segment plate having a face shaped to mate with and be mounted on any of said shoe faces and a narrow elongated strip of bonded abrasive grains integral with and supported throughout its length by the segment plate, the assembled strips having flat outer faces in a plane and outer abrading edges, and removable fasteners for mounting the plates on the shoes with the leading portions of the abrading edges spaced and arranged for a plow-like abrading action relative to the path of revolution.

3. An abrasive body according to claim 2 in which a plurality of segment plates are removably mounted on each shoe with the strips in said arrangement.

4. An abrasive body according to claim 2 comprising a wearable reinforcing body of bonded granular material on the segment plate engaging and reinforcing the side of the abrasive strip which is capable of wearing away as rapidly as the strip and supports the strip laterally without interfering materially with the abrading operation.

5. A segmental abrasive chuck comprising a rotary plate, a shoe removably mounted thereon with an outer exposed face, selectively interchangeable abrasive units independent of the shoe including elongated segment plates and narrow elongated flat surfaced bonded abrasive strips integral with and fully supported by the segment plates and which have arcuate outer abrading edges, each segment plate mating with and being mounted on the exposed face of the shoe, and fasteners for removably mounting any of the segment plates on an exposed shoe face with the flat surfaces of the abrasive strips lying in a plane and arranged in a path of revolution with the leading nose of each strip located inwardly of the trailing end of the preceding strip and the leading portion of each outer arcuate edge more nearly tangential than radial relative to the path of revolution.

6. An abrasive tool comprising a shoe having an under face and side faces arranged for mounting in the clamps of a rotary chuck, a segment removably mounted on the shoe and having a portion projecting beyond the side faces and an arcuate abrasive strip mounted on the under side of the segment and said portion, said segment and

strip constituting an abrasive unit which is longer than the shoe and is mounted on the shoe obliquely relative to its rotary direction of motion.

7. In combination with a rotary chuck carrying a plurality of clamps thereon, a set of separate interchangeable shoes removably mountable in the clamps and having ledges providing under faces projecting beyond the clamps, a set of segment plates removably and interchangeably mounted on the shoes, and abrasive strips fixedly secured on the segment plates which have portions underlying said ledges and being longer than and projecting beyond the shoes, each of said strips having a curved edge portion and being mounted on the segment for revolution in a non-concentric relationship relative

the chuck axis and thereby providing a lateral sweeping action across the work.

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