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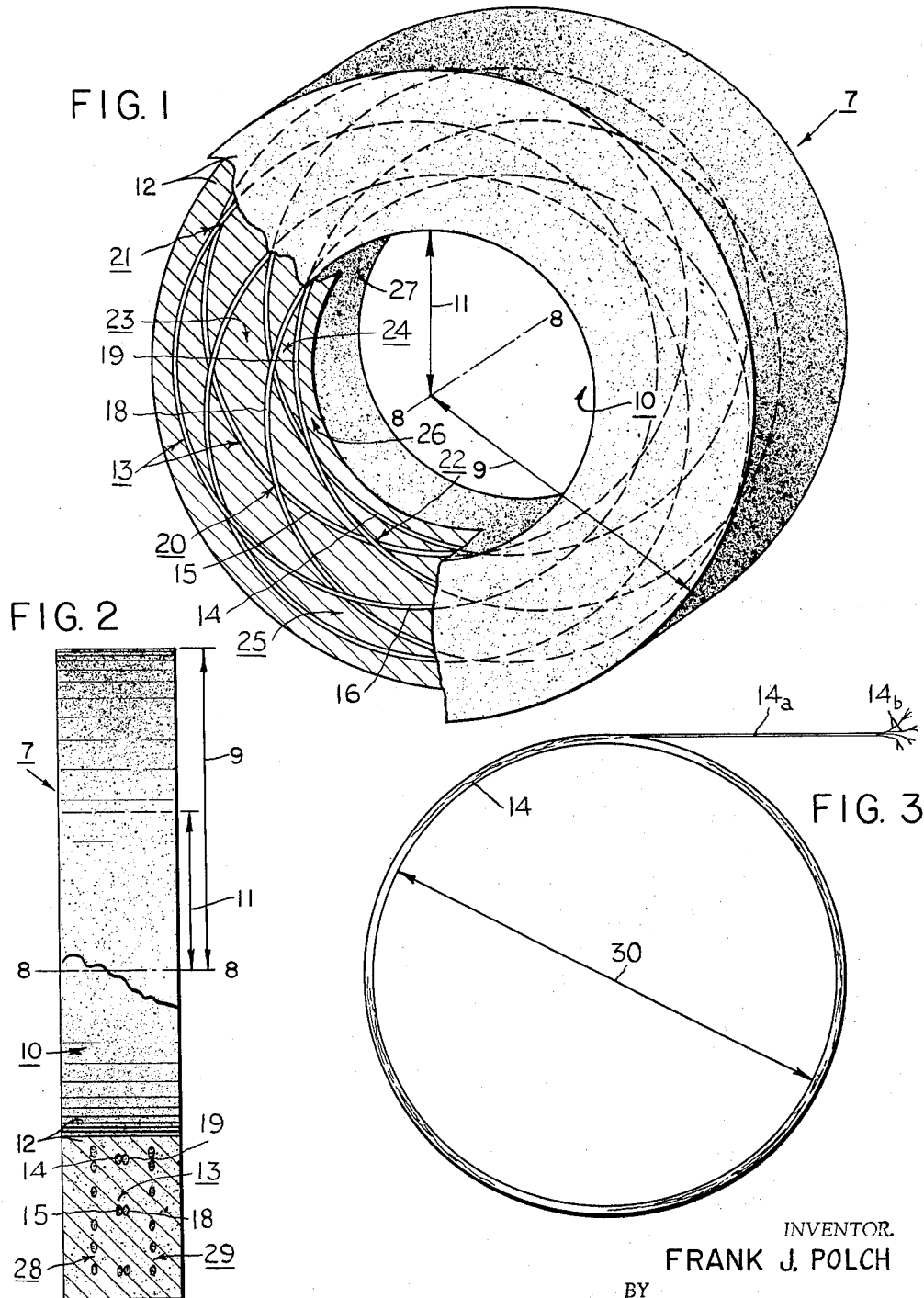
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INTERNAL REINFORCEMENT OF MOLDED ROTATABLE ARTICLES

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2 Sheets-Sheet 1



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FIG. 4

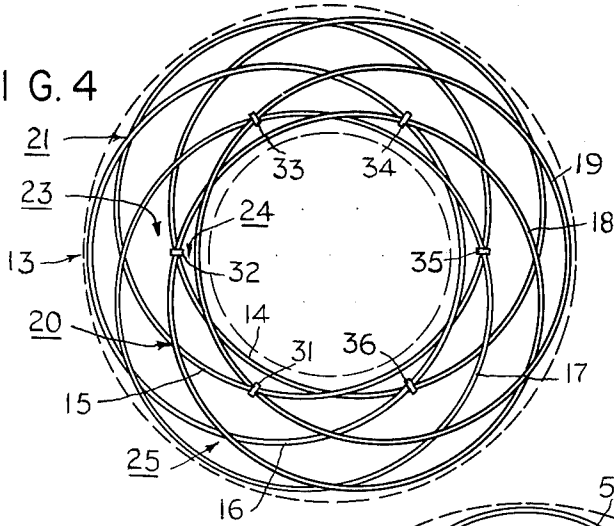


FIG. 6

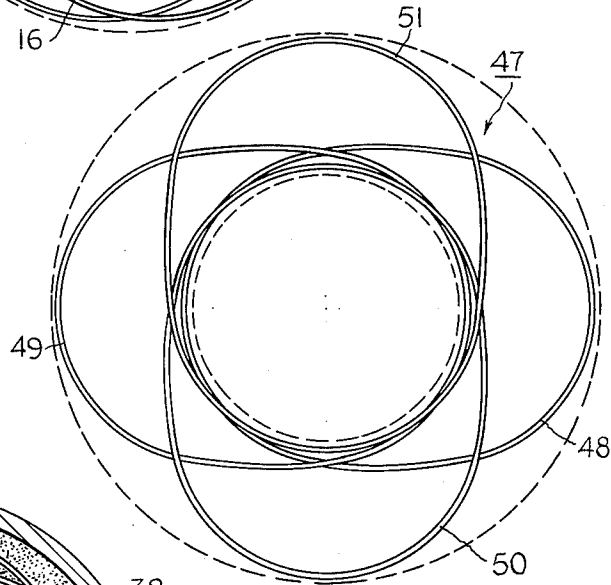
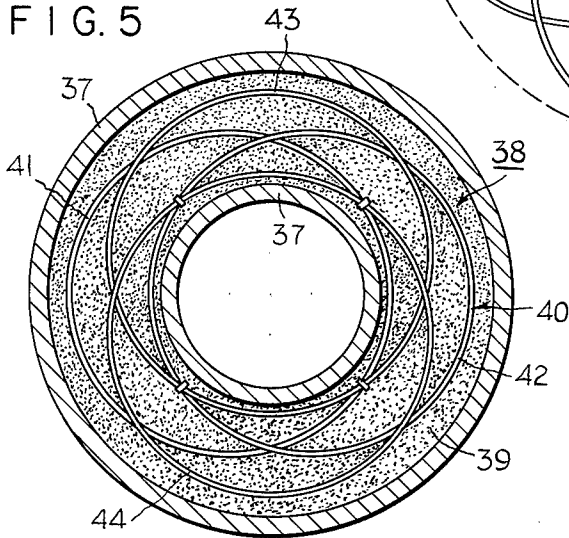


FIG. 5



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INTERNAL REINFORCEMENT OF MOLDED ROTATABLE ARTICLES

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The present invention relates to improvement of strength of rotatable molded items such as abrasive wheels and the like, and, in one particular aspect, to novel and improved internal reinforcement of high-speed and highly stressed grinding wheels involving high-tensile-strength fibers economically wound into loops which are uniquely arrayed to enhance structural integrity and to minimize accidental release of parted fragments.

Both internal and external reinforcements of a variety of forms have been exploited heretofore in the manufacture of certain types of abrasive wheels and discs. Generally, such reinforcements are adopted for purposes of simple strength compensation, whenever it is considered that the molded abrasive body alone may prove to be so mechanically weak that it cannot readily withstand rigorous operating conditions, and, secondly, as a safety precaution, to entrap and prevent the hazardous escape of fractured sections which may tend to part accidentally from the somewhat frangible abrasive wheel while it is spinning rapidly. Woven meshes, discs, bars, and strands have been proposed for reinforcements, and some of these have included such diverse materials as hard and soft metals, glass fibers, nylon, and paper; geometrically, the strengthening provisions have assumed a variety of forms, such as concentric rings, polygons, and helical or spiral windings. A fabrication technique commonly practiced in manufacture of molded abrasive wheels involves the bonding of abrasive particles or grains within a matrix of resin or comparable binder material which can be eroded and dissipated as the wheel is progressively worn from its encounters with workpieces; in providing internal reinforcement for articles made in this way, it is important that the reinforcing material be distributed to perform its functions well at all critical positions, be strongly interlocked mechanically with the abrasive mixture, be arranged to permit maximum exposures of the abrasive substance as the wheel is worn to reduced sizes, be protected against weakening damage during the molding process, and that it be in form lending itself to rapid and economical installation with common levels of skill. The case of reinforcements made of woven cloth-like meshes well illustrates certain of the difficulties; if the weave is formed close for purposes of developing maximum strength in the mesh, then relatively large particles of a gritty abrasive mixture will not penetrate the interstices where needed for optimum mechanical interlocking and for most uniform distribution of the abrasive, and, if on the other hand the weave is made more coarse or loose, the reinforcement strength available from the mesh may be materially reduced. Elongated strands and cords of strands offer high tensile strengths, but it has been found difficult to fashion these into appropriate patterns which will provide optimum reinforcement of an abrasive wheel, particularly one having a mounting or center hole, and while will at the same time provide maximum exposures of abrasive particles as wear occurs. In accordance with the present teachings, however, these difficulties are avoided and significant improvements in wheel strengths and in the ease and economy of high-speed abrasive wheel manufacture are realized by winding continuous high-tensile-strength strands into strong cord loops, and by arranging these loops in an angularly-offset overlapped relationship wherein each loop is ec-

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centric and has extensive wrap-around about the mounting hole of the circular wheel within which they are molded.

It is one of the objects of the present invention, therefore, to provide improved reinforcement of molded rotatable articles having mounting or center holes which are each defined by the internal diameter of the wheel, such as high-speed abrasive snagging wheels and the like, wherein strength is enhanced by overlapped loops of high-tensile-strength cords which have large wrap-around about the center hole and which are interlocked with abrasive material in a manner tending to prevent accidental separations of fragments and to allow exposures of optimum amounts of the abrasive as wear progresses.

Another object is to provide a novel and beneficial method for the fabrication of reinforced high-speed grinding members wherein structural integrity is improved by internally-molded cord loops.

A further object is to provide unique looped-cord reinforcements for the economical manufacture of abrasive wheels having central mounting holes.

Still further, it is an object to provide massive rough-grinding wheels wherein strong internal webbing, which promotes safe increases in speeds and operating efficiencies, is developed economically from a plurality of overlapped looped cords formed of continuous strands of high-tensile-strength material.

By way of a summary account of the practice of this invention in one of its aspects, an abrasive snagging wheel, of the type intended for mounting on a swing frame grinder and for use in the rough removal of surface imperfections from billets or castings, is molded from a composition including abrasive grains, the molded article including an internal reinforcement made up of multi-strand cord loops which are overlapped in angularly offset relationship to develop a web with large interstices. Each of the plurality of cord loops is fashioned of a multitude of continuous filaments of glass, or the like, having very high tensile strength, these filaments preferably being wound through numerous turns in grouped form as "ends" or "strands." Each resulting thick cord is substantially continuous, rather than having a discrete juncture between ends, and thus maintains high tensile strength throughout. For example, the cord loops are substantially circular, and are of a diameter equal to about the sum of the radius of the wheel which is to be reinforced and the radius of the central hole of the same wheel. Loop stiffening is achieved by curing after they have been impregnated with a resin which is compatible with the material to be used in bonding the abrasive grains into a molded wheel. A plurality of the stiffened cord loops are arranged tangentially with the periphery of the wheel and with the body of the wheel intended to be reinforced, with the loops being overlapped and angularly offset by substantially equal amounts to produce a symmetrical and balanced array. To promote integration of the loops into a self-sustaining web, firm junctures between the loops are made at a number of sites, and preferably substantially all of the sites, where they overlap one another; this may be done by tying or clipping, or by adhesive bonding. Subsequently, the web is placed in an annular mold and surrounded by a dry mix of abrasive particles and bonding resin, the relatively large interstices between the overlapped cord loops being filled with the mix to eliminate possible voids, and the mix is compacted and cured to form an integrated combination of the web, abrasive particles, and binder, in a solid grinding wheel. The resulting annular product is found to be heavily reinforced about its central mounting hole, because of the extensive wrap-around of the cord loops in that vicinity, and the other portions of the loops are elsewhere well distributed

and well interlocked with the abrasive mixture to augment wheel strengths in bending and impact, as well as to prevent the accidental separation of fragments if the wheel should become cracked under severe dynamic operating conditions.

Although the aspects of this invention which are believed to be novel are set forth in the appended claims, additional details as to preferred practices of the invention and as to the further objects, advantages and features thereof may be most readily comprehended through reference to the following description taken in connection with the accompanying drawings, wherein:

FIGURE 1 is a pictorial representation of a reinforced abrasive wheel, a portion of which is broken away in the illustration to expose the structure of improved internal reinforcement webbing;

FIGURE 2 provides a partly cross-sectioned side view of a reinforced grinding wheel such as that of FIGURE 1;

FIGURE 3 shows a partly-wound endless loop of glass filaments used in the fabrication of an improved reinforcement web;

FIGURE 4 illustrates a sub-assembly in the form of a six-loop reinforcement web for internal strengthening of high-speed rotatable annular articles having large internal diameters;

FIGURE 5 portrays a partly-filled annular mold, shown in cross-section, in which a four-loop reinforcement web is packed with abrasive particles and bonding material for the molding of an improved grinding wheel; and

FIGURE 6 depicts a reinforcement web structure in which wrap-around about the inner periphery of an annular reinforced article is enhanced as the result of a generally elliptical configuration of the web loops.

The molded annular abrasive snagging wheel 7 illustrated in FIGURES 1 and 2 is of type commonly used in the rough removal of surface imperfections from castings or billets, or the like, and is intended for rotation at high speeds about the axis 8—8 on a suitable hub on a swing frame or other type of snagging grinder, the wheel being frequently subjected to very forceful impacts under heavy pressure conditions with the work. Such a snagging wheel generally possesses a relatively large overall radius, 9, and is provided with a central mounting hole 10 having a relatively large radius, 11, these proportions resulting in a conservation of the molded abrasive material, 12, to avoid wheel formation where it is not actually needed for optimum grinding purposes. However, rotational stresses in the abrasive body are found to increase with increase in the ratio of inner hole diameter to the overall wheel diameter. It is found that the optimum compositions for grinding purposes do not possess sufficient mechanical strength to safely permit the increased operating speeds which are desirable for purposes of promoting faster removal rates, cooler grinding, improved surface finishes, freer cutting, and reduced metal-loading. Moreover, the grinding wheels which have large hub openings tend to develop cracks and like weaknesses near their inner peripheries when rotational or total stresses are increased substantially; and, these faults can enlarge and result in hazardous release of fragments. It is for such reason that resort has been had to use of internal reinforcements such as those noted earlier herein, although with but limited success and without the advantages obtainable with the improved reinforcement webbing such as that designated by reference character 13. In the simplest form of my reinforced wheel, this annular webbing lies in essentially one plane in centrally transverse relationship to the wheel axis 8—8 and is embedded within and bonded to the molded abrasive composition 12, and comprises six continuously-wound circular loops 14—19 of high-tensile-strength material such as glass strands. The individual loops 14—19 are each of substantially the same diameter, equal to about the sum of radial distances 9 and 11, are each eccentrically

disposed in relation to the axis of rotation 8—8, and are each further disposed in substantially tangential relationship to both the inner and outer peripheries of the annular wheel. These loops are overlapped with one another, as the result of close stacking in the same sequence as they are numbered (i.e., 14 through 19), with the successive loops in the stack being angularly offset from one another about axis 8—8 by substantially the same angular amount, 60 degrees. Web 13 is thus symmetrical about axis 8—8, to prevent the introduction of imbalance which might impair dynamic balancing of the grinding wheel. At a plurality of sites (thirty in the illustrated web), such as sites 20—22, the loops are closely overlapped, and relatively large and symmetrically distributed interstices (third in the illustrated web), such as interstices 23—25, are formed between enclosing portions of the loops. Abrasive composition which fills these interstices is thus firmly secured by the enclosing portions of the overlapped loops. In this improved type of structure, all of the loops extend very nearly transversely to the radial directions in which wheel cracks have a tendency to develop, and the reinforcements attained are thus very nearly optimum; in this connection, it is acknowledged that concentric circular loops of course promise even better reinforcement for suppression of radial cracking, but such concentric loops become continuously exposed about the periphery of the grinding wheel as it is worn, thereby undesirably reducing the amount of abrasive compound exposed to the work. By way of distinction, it should be noted (FIGURES 1 and 4) that the overlapped angularly-offset eccentric loops 14—19 cannot be so continuously exposed upon occurrence of wear, such that relatively large areas of abrasive compound will be brought into contact with the work at each axial position along the outer periphery of the grinding wheel where it engages work during its rotation. Advantageously, the molded composition located at annular position 26 near the inner periphery 27 of the wheel is fully and closely encircled by the radially innermost portions of the overlapped loops 14—19 which each exhibit desirably large wrap-around; this inner peripheral reinforcement in a substantially circular path is particularly valuable in preventing the formation and spread of wheel cracks.

Relatively thick wheels preferably include more than one reinforcing web, and three such webs 13, 28 and 29, are therefore illustrated in FIGURE 2. In the illustrated arrangement, the loops of webs 28 and 29 are angularly offset in relation to those of web 13, to improve their combined holding effect on the material secured within their interstices, although it should be understood that the webs are otherwise preferably of like structure.

Individual loops, such as the loop 14 shown in FIGURE 3 are produced by winding a plurality of turns of a continuous multi-filament strand 14a in a circular path, preferably about a circular form of suitable diameter 30, to develop a relatively thick and continuous circular high-strength cord. In one application of glass-fiber material, which possesses high tensile strength and is metallurgically inert and readily broken away when it encounters the work being ground, about sixty "ends" 14b each including about one hundred and twenty-five substantially continuous individual glass filaments may typically constitute a single "strand" 14a. Six of these wound cord-like continuous loops, each including a multiplicity of filaments, are overlapped in the eccentric angularly-offset array depicted in FIGURE 4 to form a single symmetrical and balanced web, 13, the illustrated loops being stacked in the order of their numbering, 14—19.

As an aid to handling, and packing of the webs in a mold, the overlapped loops are secured together at a plurality of the sites where they overlap. Metal clips 31—36 are shown binding the overlapped loops at these sides, and serve to prevent them from slipping from their illustrated

positions in the annular array. Alternatively, various known forms of ties or fasteners may be employed or, preferably, the binding may be achieved by a resin or other bonding material at these sites. The latter practice is particularly convenient when the loops, and the web as a whole, are artificially stiffened by applying and curing a coating of resin which is compatible with and will become integrally bonded with the resin binder used with abrasive particles in the molding composition. Liquid resin may be used to coat the strands before they are wound into cord loops, or the cords may be impregnated after winding, and preferably before removal from the forms on which they are developed, or both. The resin selected is preferably the same as, or at least compatible with, that which is used for bonding of the abrasive particles in the intended grinding wheel structure, such that the cords embedded in the abrasive compound will become integrally bonded with it. One example comprises a phenol formaldehyde resin, in powder form, dissolved in alcohol. Application of the liquid resin may be by way of wiping the strands as they are being wound, or by way of brushing or spraying of the cords after they have been formed; further, additional amounts of the same type of resin may be applied at the overlap sites of binders 31-36, to secure the loops together. Curing of the resin, as by baking in an oven or by simple drying or by flow of heated air across the coated surfaces, causes the loops to become stiffened and thus lend themselves, either singly or in a web, to ready handling. Curing, or at least partial curing of the individual loops facilitates their stacking in an array such as that of FIGURE 4, and curing of the completed web in turn facilitates its being placed in and properly oriented within a mold for the production of an abrasive wheel.

The latter arrangement appears in FIGURE 5, wherein a mold 37 contains an annular cavity 38 in which a dry mixture 39 of abrasive grains and powdered binding resin is packed, together with one or more resin-coated reinforcing webs such as web 40. Quantities of the mixture fill the interstices between the four overlapped loops 41-44 of the web, and the mold is filled to cover the web, after which the composite unit is cured, by hot pressing for example, to create the desired solid and fully integrated reinforced annular article. Alternatively, the article may be cold pressed in a mold, without baking, in accordance with known techniques. The resulting cold pressed "green" structure may then be treated or dressed in a conventional manner to impart to it a desired type of roughened exterior, and may be cured and fitted with an internal bushing or the like within its central opening. Any other convention bonding technique may be used such as those making use of resins that cure at room temperature.

The finished grinding wheel is found to possess outstanding strength characteristics, in cross-bending, under impact, and in suppressing the loss of fractured sections. Grinding can be performed more safely and at higher speeds, both on the faces and sides of abrasive wheels which are so reinforced. The numerous overlaps provide well distributed reinforcement which is effective even after the wheels become severely worn, and the extensive wrap-around about the mounting holes of the wheels enables the wheels to be safely operated under high stress.

In FIGURE 6 an alternative web embodiment 47 is shown to include four cord loops 48-51 which are somewhat elongated oval or elliptical in shape. These loops each have an inner end curvature closely approximating that of the central opening of the wheel which is to be formed, and thus develop desirably extensive wrap-around for purposes already mentioned herein, without requiring the use of a large number of loops. The outer ends of these loops have been shown to have about the same curvature, although they may be shaped somewhat differently and have a curvature of larger or smaller radius

or may even be somewhat pointed or otherwise shaped for example if desired.

It should be understood that the specific embodiments and practices herein described have been presented by way of disclosure rather than limitation, and that various modifications, substitutions and combinations may be effected without departure in spirit or scope from this invention in its broader aspects.

I claim:

1. A reinforced molded article having a substantially central opening, comprising a body of bonded composition, at least one reinforcement web bonded with said composition, said web including a plurality of angularly-offset individual loop portions each of which surrounds and is in eccentric relation to the opening and all of which overlap with other of said loop portions, said loop portions each being formed separately of cord having a plurality of substantially continuous high-tensile-strength filaments, and means for fixing said loop portions together at a plurality of sites where said loop portions overlap, a whole number of said loop portions being symmetrically distributed angularly about said opening with the radially innermost parts thereof in closely-surrounding relationship to said opening.

2. A reinforced molded and bonded abrasive article having a substantially central opening comprising a body of molded and bonded composition including abrasive particles secured together by a bonding material, at least one reinforcement web embedded within and bonded with said composition, said web including a plurality of angularly-offset individual loop portions each of which surrounds said opening in eccentric relation thereto and all of which overlap with other of said loop portions, said loop portions being formed separately of cord having a plurality of substantially continuous high-tensile-strength filaments, and a second bonding material compatible with said first named bonding material and being integral with said loop portions to hold the loops fixed together at a plurality of sites where said loop portions overlap, a whole number of said loop portions being symmetrically distributed angularly about said opening each with a substantially circularly curved part thereof in closely-surrounding wrap-around relationship to said opening to provide strong reinforcement of the portions of said abrasive article which closely surround the opening.

3. A reinforced abrasive article as set forth in claim 2 and wherein said second bonding material is integral with and bonds said filaments together to impart stiffness and crush-resistance thereto, and wherein said second bonding material is integral with all the cord of said loop portions to bond them together at the overlaps to preserve said web as a self-sustaining unit.

4. A reinforcement web for molded articles intended to be rotated about a center line, comprising a plurality of individual loop portions each of which has a substantially circular curvature along at least one part thereof, said individual loop portions each comprising a plurality of substantially continuous high-tensile-strength filaments, each of said loop portions being eccentrically positioned relative to the center line and being overlapped with other of said loop portions and angularly offset in relation to other of said loop portions to form a pattern that surrounds the said center line, and means binding said individual loop portions together at a plurality of sites where said loop portions overlap, whereby to form an integrated web wherein said loop portions cannot slip in relation to one another, said loop portions being symmetrically distributed angularly about the said center line to form a balanced structure.

5. A reinforcement web for molded articles as set forth in claim 4 wherein the substantially circular curvatures of said loop portions are nearer the said center line and are disposed a predetermined distance from the said center line to produce an annular web having a central substantially circular opening therein, and wherein said loop

portions are all of substantially the same size and shape.

6. A reinforcement web for a molded abrasive wheel intended to be rotated about an axis, comprising a plurality of individual substantially stiff and circular cord loops each of which is separately formed of a plurality of substantially continuous high-tensile-strength filaments coated with resin, each of said cord loops being in surrounding eccentric relationship to the said axis and having overlapped sites with other of said loops and angularly offset in relation to other of said loops about the said axis and said loops being fixed together at the plurality of sites where said loops overlap to impart self-sustaining stiffness to the web, said loops being symmetrically distributed angularly about the said axis to form a balanced web structure.

7. A reinforcement web for a molded abrasive wheel intended to be rotated about an axis, comprising a plurality of individual substantially stiff and circular continuous loops each of which is separately formed of a plurality of turns of a plurality of substantially continuous glass filaments coated with resin, each of said loops being in surrounding eccentric relationship to the said axis and having a plurality of overlapped sites with the others of said loops and angularly offset in relation to the others of said loops about the said axis, and means binding said loops together at said plurality of sites where said loops overlap to impart self-sustaining structural integrity to the web, said loops being symmetrically distributed angularly about said axis to form a balanced web structure, and the portions of said loops nearer the said axis each being disposed a predetermined radial distance from the said axis to produce an annular web having a substantially circular centrally disposed opening therein closely surrounded by said portions of said loops.

8. The method of forming a reinforcement web for molded articles intended to be rotated about a center line which comprises winding substantially continuous strands of high-tensile-strength material into a plurality of separate loops, orienting said individual loops in symmetrical angularly-offset and eccentric relationship about the said center line and overlapping each of said individual loops

with others of said loops at a plurality of points with interstices therebetween, and binding the material of said loops together at a plurality of said points to form an integrated web in which the loops cannot slip in relation to one another.

9. The method of forming a reinforced molded abrasive wheel which is intended to be rotated about an axis, which comprises winding substantially continuous strands of high-tensile-strength material into a plurality of separate loops, applying a coating of resin to the strands of said loops, mounting said loops in symmetrical angularly-offset and eccentric relationship about the said axis and overlapping each of said loops with other of said loops at a plurality of points with interstices therebetween, drying the resin coating to stiffen said loops, and molding about the loops a body of abrasive particles and binding material to form said wheel.

10. The method of forming a reinforced molded abrasive wheel as set forth in claim 9 wherein said winding comprises winding said strands into a plurality of loops each of which is continuous and of a predetermined diameter, and wherein said mounting comprises positioning the portions of said loops nearer the said axis at a predetermined radial distance therefrom to form a substantially annular web having a substantially circular central opening therein.

11. The method of forming a reinforced molded abrasive wheel as set forth in claim 10 which comprises bonding said loops together at a plurality of the points where said loops are overlapped, and molding about the web a body of abrasive particles and a binding material therefor which is compatible with said coating of resin.

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