July 26, 1966 J. A. SEYMOUR ETAL 3,262,230

REINFORCEMENT OF MOLDED ABRASIVE ARTICLES

Filed Feb. 10, 1964

3 Sheets-Sheet 1

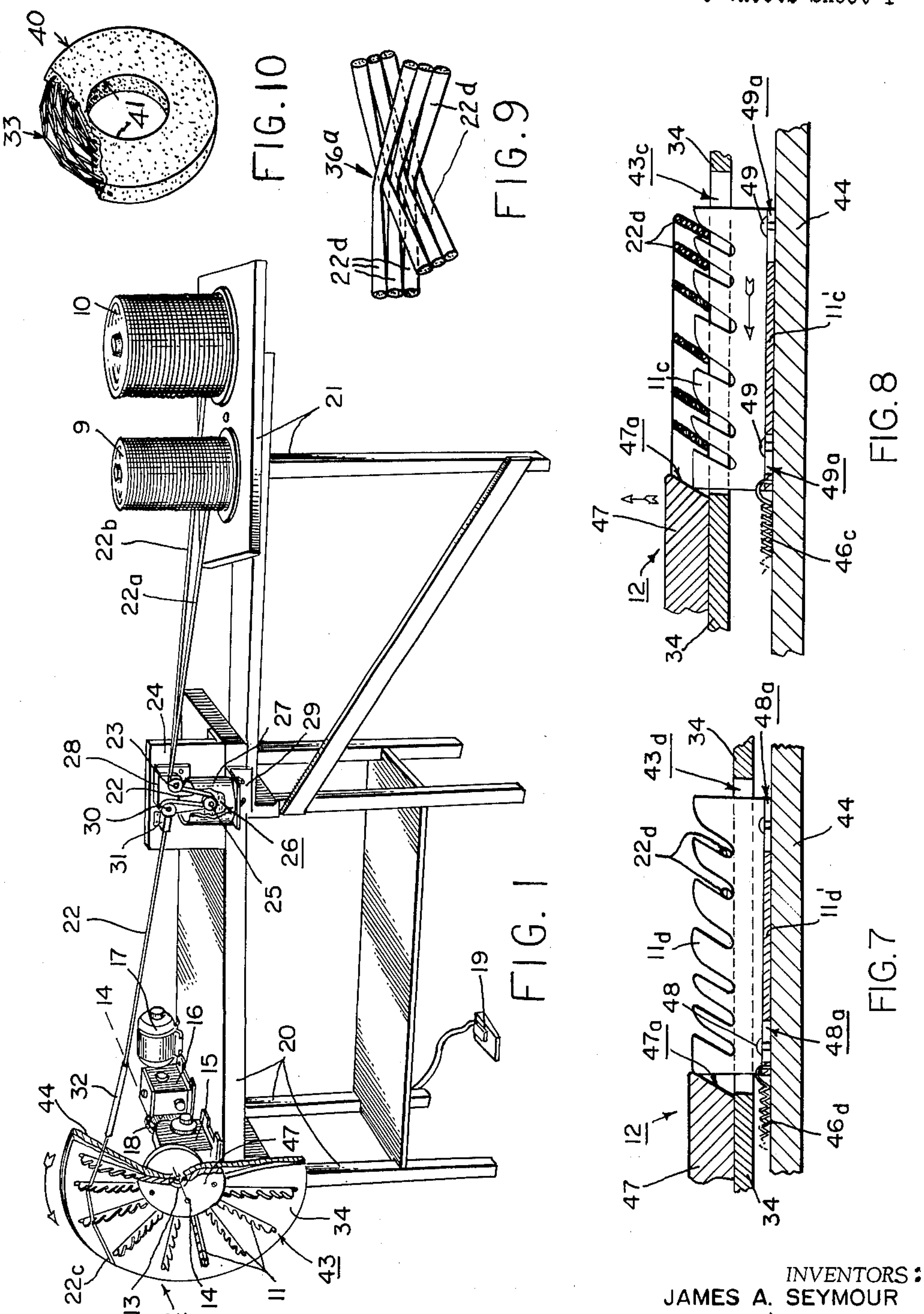
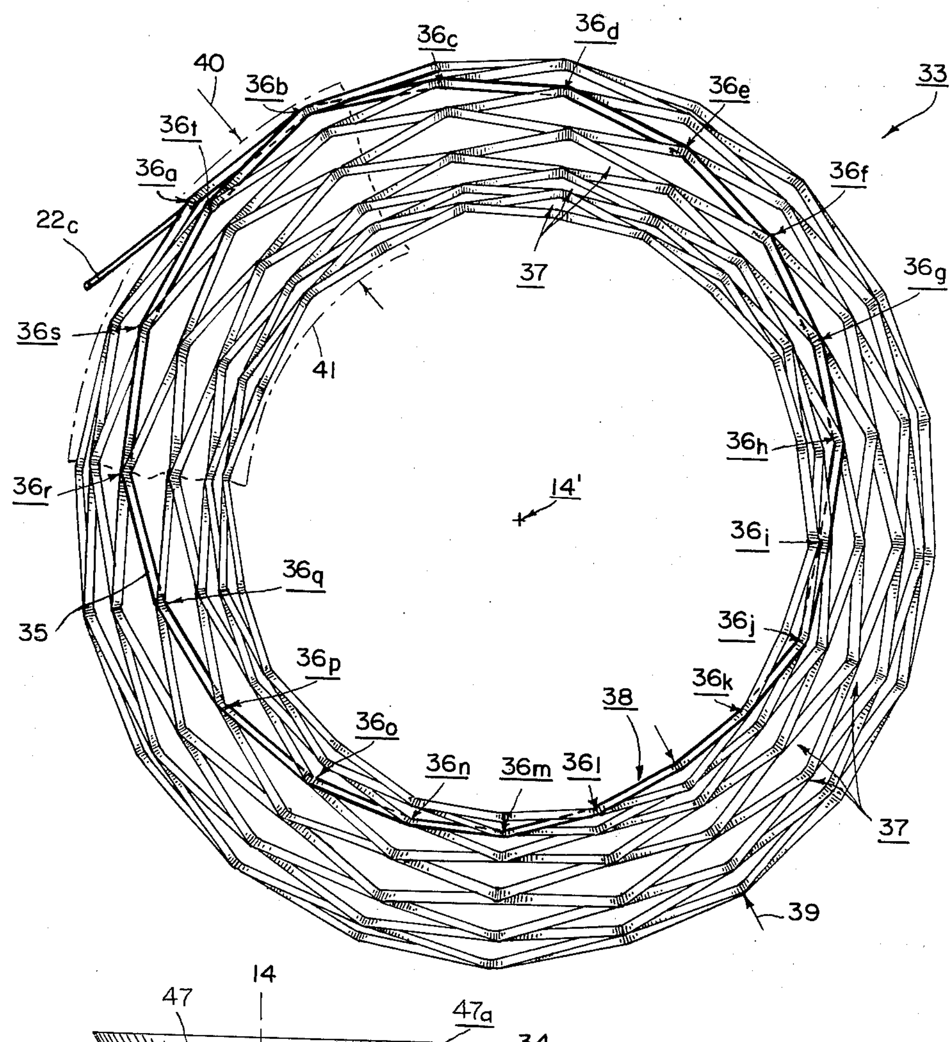


FIG. 1 FIG. 7 FIG. 8 FIG. 9 FIG. 10

INVENTORS:
JAMES A. SEYMOUR
ROBERT L. HOLDEN

BY Allan R. Redrow
ATTORNEY

FIG. 2



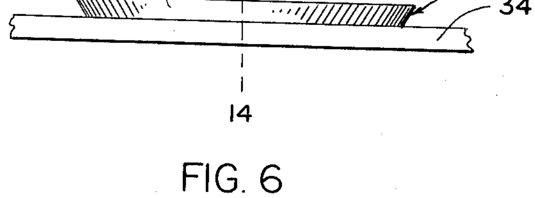




FIG. 6

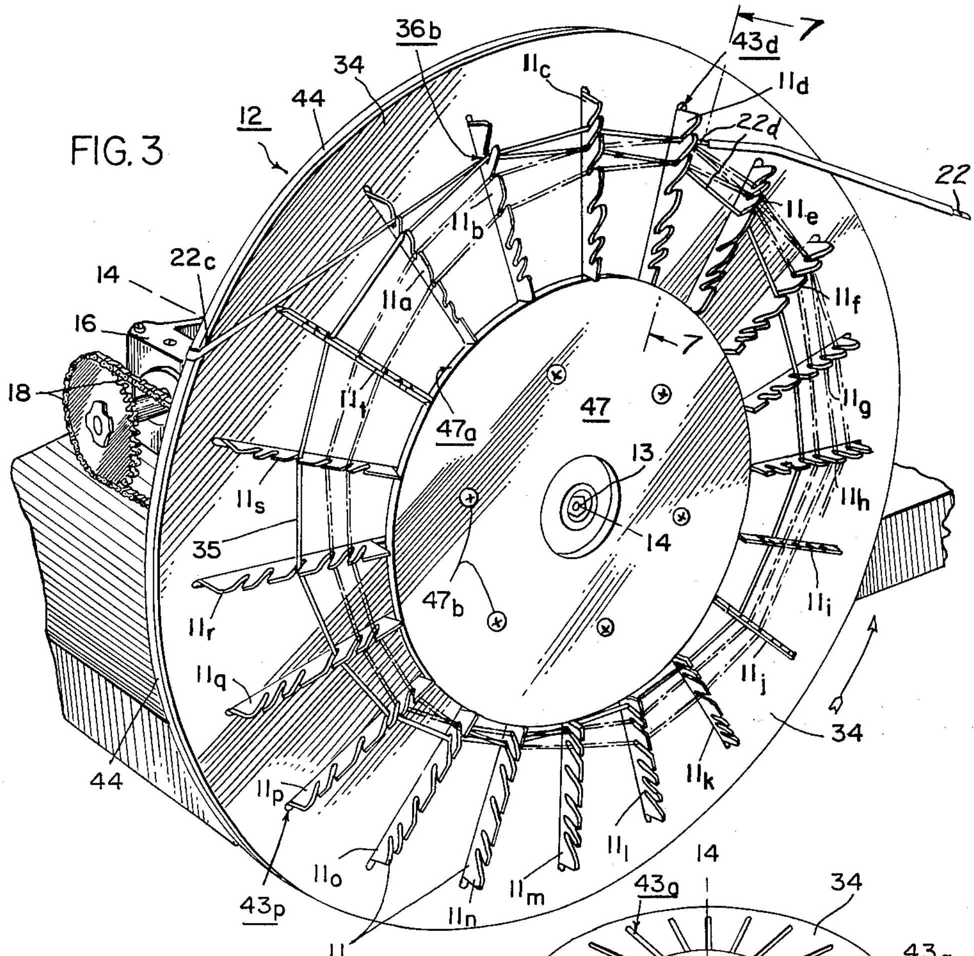
INVENTORS:
JAMES A. SEYMOUR
BY ROBERT L. HOLDEN

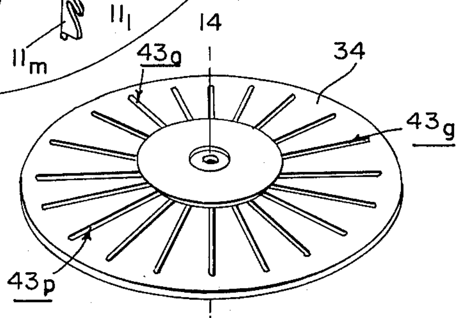
Allan R. Redrow
ATTORNEY

REINFORCEMENT OF MOLDED ABRASIVE ARTICLES

Filed Feb. 10, 1964 3 Sheets-Sheet 3

FIG. 3



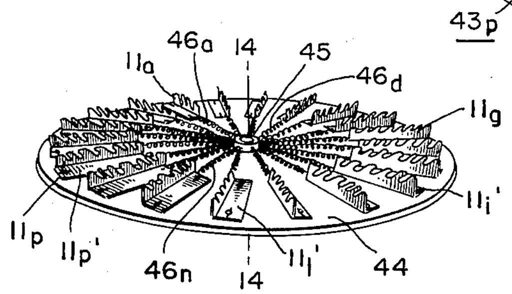




FIG.4

FIG.5

INVENTORS:
JAMES A. SEYMOUR
BY ROBERT L. HOLDEN

Allan R. Redrow
ATTORNEY

United States Patent Office

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1

# 3,262,230
# REINFORCEMENT OF MOLDED ABRASIVE ARTICLES

James A. Seymour, Warren, and Robert L. Holden, Westboro, Mass., assignors to Norton Company, Worcester, Mass., a corporation of Massachusetts
Filed Feb. 10, 1964, Ser. No. 343,792
45 Claims. (Cl. 51—206)

The present invention relates to the improvement of strength of rotatable molded items such as abrasive machining wheels and the like, and, in one particular aspect, to novel and improved internal reinforcement of grinding wheels having unique webbing provisions and which may be manufactured economically to exhibit an outstanding degree of structural integrity even when materially worn or subjected to abnormal operating conditions.

Internal and external reinforcements of a variety of forms have been exploited for some time in the manufacture of certain types of abrasive wheels and disks. In general, these reinforcements have been designed to augment the strengths of the inherently mechanically weak materials of which such abrasive articles may be made, and, especially, to suppress the accidental parting of fractured sections of the somewhat frangible abrasive material. Geometrically, these expedients have taken such diverse forms as those of woven cloth- or screen-like disks, rings, polygons, short or elongated fibers, bars, and helical or spiral strands; the materials used have included hard and soft metals, glass fibers, nylon, and paper, for example. The common fabrication technique practiced in manufacture of abrasive wheels involves the bonding of abrasive particles or grains by resin or comparable material which is otherwise inert and can be dissipated as the abrading material is progressively worn; a major problem encountered in attempted reinforcement of such articles is that of securely integrating the reinforcing elements with the composite material of the wheel, without at the same time sacrificing strength. By way of example, cloth-like mesh which is woven closely to develop more powerful restraining forces will not be as well penetrated by and locked with gritty composite abrasive material, particularly in those cases where the particle sizes are large; a looser weave, on the other hand, tends to reduce the strength available from the reinforcing cloth. Elongated strands or cord-like combinations of strands can provide high strength, although these must be carefully arranged in other than concentric circular paths, for purposes of optimizing exposures of the abrasive material as wear occurs, and these special strand arrangements tend to be difficult to fabricate and handle. 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 continuous winding of high-tensile-strength strands into a special form of self-sustaining web which is well adapted to use in the wheel-molding operations and which involves an advantageous distribution of strands and sites where the strands are crossed and interlocked.

It is one of the objects of the present invention, therefore, to provide improved reinforcement of molded rotatable articles such as high-speed grinding wheels and the like, wherein strength is enhanced at relatively low cost by continuously-wound webbing which is patterned for substantially optimum interlocking with and reinforcement of molded abrasive material.

Another object is to provide reinforcement webbing of economical manufacture and mechanical nicety for uniquely promoting strength of abrasive wheels.

A further object is to provide a novel and beneficial

2

method for the continuous winding of symmetrical and sound reinforcement webbing which improves the structural integrity of high-speed molded grinding elements even under conditions of severe wear or fracture.

Still further it is an object to provide advantageous innovations in apparatus for the manufacture of continuous strand winding of unique self-supporting reinforcements for abrasive wheels.

It is yet another object to provide massive rough grinding wheels having improved internal webbing of construction and distribution which promote safe increases in operating speeds and efficiencies.

By way of a summary account of practice of this invention in one of its aspects, a multi-filament continuous ribbon of glass fibers is impregnated with resin as it is drawn onto a special type of slowly-rotated winding form having retractable radially-distributed guides arranged to engage and shape the one continuous ribbon into a number of substantially circular loops or many sided polygonal shaped ring members which are angularly displaced from one another and are eccentric in relation to the center of rotation of the winding form. The guide arrangement and the prescribed winding of the ribbon upon them develops a full symmetrical annular web pattern having a central aperture encompassed by each of the loops; these loops each extend eccentrically to the outer periphery of the annular web, and are equally offset angularly from one another such that they overlap at a number of crossover points which are symmetrically distributed. Curing of the impregnating resin at an elevated temperature results in a stiffening of the web, including an important locking of the overlapped loops at the numerous crossover sites, after which the self-sustaining web is removed from the winding form by actuation of the retractable guides. The stiffened web is then placed in a mold and surrounded by a dry mix of abrasive particles and bonding resin, the relatively large interstices between the crossed ribbon of the loops being filled with the mix to eliminate possible voids, and the mix is pressed and baked to form an integral combination of the web, abrasive particles, and binder, in a solid grinding wheel. The resulting annular product is heavily reinforced about its large central aperture, by the closely overlapped strands of the eccentric loops, and the other portions of the internal ribbon and their crossover junctions are elsewhere well distributed both radially and angularly, to augment strengths in bending and impact, as well as to prevent the dislodging 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 web-forming apparatus in which teachings of the present invention are exploited, certain portions being broken away to expose structural details;

FIGURE 2 provides a plan view of a completed reinforcement web embodying the improved construction, with one completed loop shown darker to accentuate the form thereof.

FIGURE 3 portrays in enlargement a portion of the web-forming apparatus shown in FIGURE 1, with one complete loop shown in full lines, and the loops formed on the next succeeding two revolutions of the apparatus shown in dotted lines;

FIGURE 4 depicts a portion of a composite web-forming assembly including spring-retracted guides;

FIGURE 5 depicts a further portion of the composite web-forming assembly, including a slotted cover plate and camming member;

FIGURE 6 is an enlarged detail of the portion of the web-forming assembly appearing in FIGURE 5;

FIGURE 7 provides a cross-sectioned detail of the web-forming assembly with a guide member cammed into a position for receiving a glass-fiber ribbon thereon, taken along section line 7—7 in FIGURE 3;

FIGURE 8 illustrates elements like those of FIGURE 7, in the condition wherein the guide is shown retracted into the position it should occupy to permit removal of a formed web.

FIGURE 9 is a detailed showing of the interweaving or interlocking of the strands at the points where the overlapped loops intersect, the interweaving being produced by duplicating the web-forming process two, three, or more times; and

FIGURE 10 is a showing of a completed wheel, partly broken away with a web of this invention disposed therein.

The web-manufacturing facility depicted in FIGURE 1 is of an uncomplicated and inexpensive type designed for manual regulation of the looping of glass-fiber, or other suitable high-tensile-strength filaments drawn from rotatably mounted supply rolls **9** and **10** upon the slotted guides **11** of a web-forming assembly **12**. Preferably, the assembly **12** is in the illustrated general form of a composite wheel and is mounted for slow rotation with a hub shaft **13** about a substantially horizontal axis **14—14**. Speed-reducing gear units **15** and **16** powered by an electric motor **17** and interconnected by a chain coupling **18** serve to turn the web-forming assembly slowly counterclockwise, as viewed in FIGURE 1, under supervision of an operator controlling an electrical foot switch **19** below the mounting bench **20**. Rolls **9** and **10** are rotatable on bench extension **21** to release simultaneously two continuous rope-like strands, **22*a*** and **22*b***, each preferably comprising a plurality of "ends" which, in turn, are made up of a multiplicity of continuous filaments. In the preferred case of glass-fiber material, for example, one hundred and twenty-five continuous individual glass filaments may typically constitute a single "end," with sixty of such "ends" constituting a single "strand" in the form of "roving." As the strands **22*a*** and **22*b*** are drawn toward the web-forming assembly by motive force of the motor **17**, they are first merged into a single band **22** by their common passage partly around a guide pulley **23** rotatably affixed to a vertical bench bracket **24**. A second such pulley, **25**, is disposed below the first, at a lower position where it forces the band **22** to follow it and travel through a liquid pool **26** of bonding resin within an open-topped container **27**. The further angle bracket **28** spaces the pulley **25** from the bench bracket **24** behind it, such that it may be rotatably suspended directly within the resin pool in the surrounding container **27**. Adjustable platform **29** supports the resin container on the bench at the desired position for resin-impregnation of the glass-fiber band. The impregnated band is brought out of the resin pool over a third bracket-mounted pulley, **30**, and excess liquid resin is removed by a wiper **31** through which the band must pass. Conveniently, the wiper is disposed over the open-topped container and comprises a simple bracket-mounted holder lined with felt or the like to exert a gentle squeezing action which causes the excess resin to collect and gravitate back into the container. The resin used is preferably the same as that used for bonding of the abrasive particles in the intended grinding wheel structure; one example comprises a phenol formaldehyde resin, in powder form, which has been dissolved in alcohol.

Formation of the reinforcement web is aided through use of a tubular metal guide wand **32**, which the operator may manipulate to lay the somewhat tacky impregnated band **22** in appropriate slots of the radial guides **11** of the slowly-rotated assembly **12**. At the outset, the free end **22*c*** of the band is extended out to the periphery of the web-forming assembly, beyond the radial span of the winding guides **11**. When the web has been completed and incorporated in a finished wheel, this end may be allowed to appear on the periphery of the wheel to serve as a harmless projecting marker which unfailingly identifies a completed wheel as one including the internal reinforcement webbing. As formation of the web continues the band is then guided into certain of the guide slots in accordance with a predetermined schedule or pattern insuring the ultimate formation of multiple overlaid loops which create a symmetrical and substantially balanced web after the assembly **12** has been rotated a predetermined number of times.

For purposes of producing the particular web structure **33** shown in FIGURE 2, the web-forming assembly **12** includes twenty of the radially-disposed guides **11**, these being spaced equiangularly about the horizontal axis of rotation **14—14** (i.e. by about 18 degrees). Each of the guides projects outwardly through and substantially normally to the radially-slotted face-plate 34, and each includes six substantially horizontal slots which are somewhat downwardly inclined rearwardly toward the axis of rotation, as shown in FIGURE 3. Two irregular slot patterns are involved in the alternate guides, as an aid to the winding of the individual web loops in the preferred substantially circular form; the adjacent guides **11*c*** and **11*d*** in FIGURES 3, 7 and 8 exhibit the different slot patterns, for example. If the slot pattern of FIGURE 7 is traced on thin paper and laid over the slot pattern shown in FIGURE 8, the variation in the radial positions of the slots in the respective patterns will be more easily seen.

Winding progresses by locating the band in the first, radially outermost, slot of both guides **11*a*** and **11*b***, and then in the second slots of guides **11*c*** and **11*d***, and so forth as the assembly **12** is rotated counterclockwise (FIGURES 1 and 3), until the radially innermost slots of guides **11*k*–11*m*** are reached. The band is placed in the innermost slots of all three of these guides, and is thereafter stepped radially outwardly by one slot for each two successive guides until an outermost slot is reached at the position of guide **11*b***, which is displaced from the starting guide **11*a*** by the angular width of one sector between adjacent guides. A first full loop, **35**, is then completed. Inward stepping is not commenced in the formation of the succeeding loop until the band has first been located in the outermost slots of three guides (**11*b***, **11*c*** and **11*d***). Thereafter, the same program of winding is repeated, until a predetermined number of successive loops, each displaced angularly from the next-preceding loop by the angular amount of one sector, has been formed. To promote symmetry and balance which are desirable in the completed abrasive wheel, the windings are continued until the pattern of loop **35** is about to be repeated, either for the second, third, or in some instances a still further time.

By practicing the aforesaid winding, wherein the composite web structure is formed by guiding the tacky strands **22*a*** and **22*b*** to overlay each other as the web is built up, a structure results in which a multiplicity of continuous glass fibers are drawn taut enough around the guides to form an apparently integral flattened or ribbon-like form induced by the somewhat flat-sided slots of the guides. As the multiple loops are formed, the glass fiber strands of one loop will be laid firmly over the strands forming the other loops in the various slots in the guides; these broad-area cross-over positions, such as positions **36*a*** through **36*t*** in the case of loop **35** shown in heavy linework in FIGURE 2, become sites where the overlapped loops are securely interwoven or interlocked as shown in FIGURE 9 when the resin is either dried and hardened or partially or even cured.

The cross-over positions are distributed rather uniformly and symmetrically throughout the web and due to irregular spacing of the slots in the guides, advantageously large interstices 37 also appear symmetrically throughout the web. Later, upon molding of the wheel with the web internally, the molding material fills these interstices and thereby becomes well locked with the reinforcing web bands and yet exhibits desirably large abrasive areas to a workpiece when the wheel has become well worn. As is evident from the described winding procedure and from inspection of the web in FIGURE 2, the individual loops approach circularity but in fact are polygonal and slightly oblong. The angularities aid in the formation of small but securely intertwined or interlocked cross-over junctions, which junctions define the openings 37 by which the web is most thoroughly interlocked with the bonded abrasive mix.

Each loop is eccentric in relation to the web center 14′, with its radially innermost portion (such as portion 38 of loop 35) in a close and extensive wrap-around relationship to the inner periphery of the web. When abrasive material is molded about the web to form a large grinding wheel having a large inner diameter, such as a snagging wheel, for example, these close wrap-around portions afford a very advantageously strong reinforcement about its vulnerable inner periphery. The radial width 39 of the annular reinforcement web is usually designed to be just a little less than the radial width 40 of the wheel 41 which is to be molded about it, see FIGURES 2 and 10.

Adjacent ones of the guides 11*a*–11*t* are slotted differently, with their respective first (radially outermost) and sixth (radially innermost) slots at about the same radial distances from the axis 14—14, while intermediate slots (such as the second through fifth) are radially offset or stepped in relation to one another so that the slots in one are located at radial positions between those of the slots of the other. A comparison of the guides 11*b* and 11*c* in FIGURES 7 and 8 shows that such a stepped relationship exists; as a result of these differences in slotting, the wound band is first caused to step radially inwardly and then radially outwardly in a gradual manner as each loop is formed, even though it is successively wound upon two of the slots of the same number (second through fifth) in adjacent guides. The complex web, having distributed cross-over junctions and interstices, and having a particularly high degree of wrap-around reinforcement about its inner periphery, has the appearance and strength characteristics which would be expected only in an interlaced or woven construction, although the manufacturing difficulties and costs of the latter are avoided. Laborious clipping, pinning, or separate gluing of the multiple cross-over functions is unnecessary, inasmuch as the tacky fibers of the overlaid and mingled strands become solidly joined to form in effect a ribbon when their resin coatings are hardened.

The specific twenty-guide assembly 12 chosen for description produces a full symmetrical and balanced web when eleven loops have been completed in accordance with the above described winding practice. Once the full web has been produced one, two or more times, it is readily removable and maintains the form of a self-sustaining article lending itself to storage and to convenient handling in later wheel-fabrication operations. In this connection, the resin coating of the fibers is important in that it stiffens the ribbon-like bands when it has been sufficiently dried or cured; otherwise, the glass fibers, which possess outstanding strength characteristics in tension, would be somewhat limp and the web would not preserve the fixed shape which is desired to simplify and improve the accuracy of the wheel molding operations. Stiffening, and bonding of the cross-over junctions, can be achieved by placing the fully wound web-forming assembly 12 in an oven after it has been removed from shaft 13, and by then baking the resin; alternatively, the web may be dried or cured in air, preferably with the aid of a hot air jet, and preferably while the web is being wound.

Inclination of the guide slots promotes optimum winding of the web and prevents accidental slippage of the loops from the rotated assembly 12; however, the stiffened complex web is locked with and not readily lifted from the assembly unless the guides are prevented from interfering. It is for purposes of such web removal that the guides are not immovably attached to faceplate 34 and are, instead, mounted on a back support plate 42 and are radially slidable, to a certain extent, in the radial slots 43*a*–43*t* of the faceplate through which they project. The guides, 11*a*–11*t*, are individually mounted for limited radial sliding movements on the front of a back plate 44 which is of essentially the same diameter as the faceplate and is mounted coaxially with it on the driven shaft 13 about the axis 14—14. Central hub member 45 (FIGURE 4) serves as a spacer and as an anchor for inner ends of radially disposed springs 46*a*–46*t* which are connected to the guides 11*a*–11*t* and act to draw them radially inward. When the plates are secured closely together, in the manner shown in FIGURES 1, 3 and 7, all of the guides 11*a*–11*t* are spread radially outwardly by the camming action of the rearwardly—and inwardly—inclined peripheral surface 47*a* of a central cam plate 47 which is fastened to the front of faceplate 34 by a plurality of bolts 47*b*. The guides are conveniently fabricated in right-angle form, with their flat bases 11*a*′–11*t*′ each held in abutting relationship to the back plate 44 by a pair of large-headed bolts, such as the bolts 48 and 49 in FIGURES 7 and 8. Radially-oriented elongated slots, such as slots 48*a* and 49*a*, maintain radial alignment of the spring-restrained guides. As the two plates 34 and 44 are forced together, the camming surface 47*a* urges all of the radially innermost upstanding edges of the guides radially outwardly to the positions intended during the winding of the reinforcement web.

Once the full web has been formed and stiffened upon the guides, the cammed faceplate 34 is lifted from the back plate, and the cam surface 47*a* no longer prevents the biasing springs 46*a*–46*t* from drawing the guides inwardly to positions where they can release the web. The slope of cam 47*a* is selected with due consideration of the slope of the slots in guides 11 so that the completed web may be lifted free from the slotted guides when the guides are fully retracted. The release action is evident from a comparison of the relationships illustrated in FIGURES 7 and 8; the wound portions 22*d* of band 22 are raised, in FIGURE 8, and are freed from the guide slots, by the lifting of faceplate 34 while the guides are unrestrained by cam surface 47*a* and are drawn radially inwardly by the springs.

One or more of the stiffened balanced webs may be used in the fabrication of an abrasive wheel or other molded article. A conventional practice in molding of an abrasive wheel involves the substantially uniform mixing of granular abrasive particles with a dry powdered binder, such as a resin, after which this mixture is placed in a suitable mold and heated to cause a desired fusion and integration by way of the resin. It is obvious that any other conventional mix could be used in the form of a semi fluid or fluid condition for integration with the herein disclosed safety web. A generally comparable technique may be exploited using the reinforcement webs wherein a layer of the mixture is deposited in the mold, and a stiffened web is then placed upon the layer and covered fully with additional amounts of the mixture so that the interstices are well filled. Another, or several other webs may then be added and similarly covered and filled, after which the composite unit is cured by hot pressing, for example, to form a solid annular article, preferably with the outer winding ends such as end 22*c* exposed. Alternatively, the article may be pressed or otherwise formed cold in a mold with the reinforcement webbing in place, and subsequently subjected to a known curing operation. The hot or cold pressed and fully cured wheel may then be treated or dressed in the usual way to impart to it a desired type of roughened exterior, and may be fitted with an internal bushing or the like.

Resins used in fabrication of the reinforcement web or webs, and in the molding composition, are preferably the same (such as phenol formaldehyde), or are of other kinds such as epoxy resins which are compatible with the grain bonding resin such that the web is strongly bonded with the abrasive particles and their binder.

The finished wheel is found to possess outstanding strength characteristics, in cross-bending, under impact, and within the limits of the tensile and shear strength of the web fabric, in preventing the loss of fractured sections to a remarkably greater degree than has ever been possible heretofore. These characteristics are especially advantageous in high-speed large-diameter snagging wheels which have large central apertures and which are intended for very rough usage involving forceful impacts. Grinding can be performed more safely and at higher speeds, both on the faces and edges of abrasive wheels which are so reinforced. As the wheel is worn away in use, the worn bands of fibers which are encountered at its surface are found to be discontinuous in the direction of grinding and thus always leave ample abrasive surfaces exposed to the workpiece.

The minute glass (or nylon, cotton, polyester, etc.) fibers in the reinforcement web or wire from which the web may be formed, are advantageously inert metallurgically and tend to break or wear away readily upon engaging the workpiece, and yet the unexposed internal fiber or wire web elements exhibit very high tensile strengths and greatly enhance the strength of the abrasive compound with which they are interlocked and which, alone, possesses only a relatively low modulus of elasticity. The numerous distributed cross-over sites, where the number of strands are well interlocked and bonded, preserve proportional reinforcement strengths of the worn wheels even though the outer portions of the bands may be ground away. Crushing of the fibers is to be avoided during fabrication of the reinforced wheel if the desired strengths are to be preserved, and, in this connection, the resin, rubber, or other well known coatings that may be applied to the fibers before winding tend to isolate them from such crushing, particularly by the rough abrasive particles with which they are compacted during the hot or cold pressing operation. In addition, the generally circular configurations of the loop, and the relatively shallow bendings across the slotted guides, do not involve sharp taut bendings which might damage or fracture the strand or fibers. The strand or filament from which the web is formed, may be in the form of roving, yarn or thread, formed of natural or synthetic fibers or glass filaments or even wire.

Generally, it is preferable to utilize two or more spaced substantially planar webs in the fabrication of a thick wheel, rather than a single thick web, inasmuch as the thicker web could otherwise tend to surround such large isolated sections of the abrasive composition within its interstices that these wide sections or slivers of the abrasive might tend to become dislodged when the wheel has been worn. In some wheel constructions, the configuration may depart from a substantially planar form and may, for example, be conical; in such instances, the reinforcement webbing may likewise be of corresponding configuration. The conical webbing may be produced in the manner described, for example, using a conically-shaped winding assembly rather than one which is essentially flat; other variations including a cylindrical and/or non-circular pattern can be made to meet specific needs. Wheel sizes and the strengths desired for then, will largely determine the number of loops used in various webs; and the number of fibers used in fashioning the winding ribbons.

It is apparent that web designs for larger or smaller wheels may be made and more or less than twenty guides may be used in the assembly apparatus. The number of radial guides and the specific slot spacing pattern and number of slots formed in each guide may be varied to provide a web having predetermined strength characteristics depending upon the design required.

In lieu of slotted winding guides, pins or the like may be substituted. Guide wand movements may be controlled automatically, or, alternatively, the wand may remain fixed in position while the rotating web forming assembly is eccentrically rotated relative to the fixed wand. For the latter purposes, sun and planet gear mechanisms and movements may be employed, in accordance with the recognition that the desired loops are threaded in the path of a satellite revolving at a substantially constant distance (i.e., a substantially circular orbit) around a planet which, in turn, is revolving at a substantially constant distance from a sun, with the rotational period of the satellite being faster than that of the planet.

Reinforcing discs or safety webs of this invention have been formed for a 24" wheel as here shown, the pattern being formed of strands **22*a*** and **22*b*** of glass fiber roving having a tensile strength of approximately 300 lbs. per strand. The strands were pulled from a supply as shown in FIGURE 1 and run through a resin varnish bath made by dissolving powdered phenol formaldehyde resin in alcohol to produce a varnish of about 700 centistokes viscosity. The strands were wound on the web forming wheel as above described and the varnish was dried in situ to remove most of the alcohol in order to stiffen the varnish to render the web manageable and to integrate the strands at the cross-over sites. The guides **11** on plate **44** were then freed from the completed web by separating plates **44** and **34**. A number of webs so produced have been incorporated in snagging wheels in a known manner by placing the web or webs in a desired position in the mass of the wheel.

This safety web structure has been used in heavy duty snagging wheels that were subjected to extremely abusive operating conditions. Such wheels were made by the hot pressing procedure wherein the reactive phenol formaldehyde powdered resin was thoroughly mixed with the abrasive, the mixture was confined in a mold and pressed while the resin was heated to a curing temperature in the order of 175° C.—steam heated presses were used. Wheels thus produced have a very low porosity in the order of 2% or less. The usual fillers were also included in the mix.

White we have, for the purpose of illustration, described this web for use in a snagging wheel, it is obvious that it may be incorporated in any other type of reinforced wheel or may be produced in a form adapted to be placed on the outside of thin cut-off wheels. It may also be used within the mass of or on the surface of a conical wheel or for reinforcnig a cylindrical wheel in an obvious manner. Any of the wheels with which this web form is adapted to be used, may be cured in a known manner such as by hot pressing or by cold pressing and subsequent oven curing or the like.

Higher surface speeds are safely attainable with wheels having webs therein of this structure, which higher speeds produce cooler grinding, freer cutting, and improved finishes.

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

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A reinforced molded article rotatable about an axis, comprising a body of molded composition having a relatively low modulus of elasticity, at least one reinforcement web bonded integrally with and embedded within said composition and including a substantially continuous band wound into a plurality of substantially circular oblong loops which are angularly offset by substantially

equal amounts about said axis and are eccentric in relation to said axis, said band being made up of a plurality of substantially continuous filaments of material having a relatively high modulus of elasticity, the filaments of each of said offset loops being overlapped and mingled with the filaments of the other of said loops at a plurality of cross-over sites, and a cured bonding composition coating said filaments and securely bonding said mingled filaments together at said cross-over sites.

2. A reinforced molded article as set forth in claim 1 wherein said body composition includes abrasive particles and a binder material for said particles, and wherein said cured bonding composition includes a material compatible with and integrally bonded with said binder material.

3. A reinforced molded article as set forth in claim 2 wherein said band of filaments is in the form of a substantially flat ribbon lying in planes which are not perpendicular to said axis, said web having interstices between said cross-over sites distributed substantially uniformly about said axis, with said body composition including abrasive particles filling said interstices.

4. A reinforced molded abrasive wheel, comprising a body of abrasive particles secured together by binder material, at least one reinforcement web embedded within said body and including a substantially continuous band of high-tensile-strength material wound into a plurality of substantially circular full loops which are angularly offset and are eccentric in relation to the center of the wheel, each of said loops being overlapped with other of said loops at a plurality of cross-over sites, and means securely bonding the material of said loops at a plurality of said cross-over sites to form an integrated web independently of the embedding thereof within said body.

5. A reinforced molded abrasive wheel, comprising a substantially annular body of abrasive particles secured together by binder material, at least one reinforcement web embedded within said body and including a substantially continuous ribbon made up of substantially continuous high-tensile-strength filaments wound into a plurality of like oblong generally circular loops which are angularly offset and are eccentric in relation to the axis of rotation of the wheel, filaments of each of said offset loops being overlapped and mingled with filaments of the other of said loops at a plurality of cross-over sites and leaving interstices between the offset crossed-over loops, said interstices being filled with said abrasive particles and binder material, and means securely bonding together the filaments of said loops at said cross-over sites.

6. A reinforced molded abrasive wheel as set forth in claim 5 wherein said oblong loops comprise a whole number of full loops angularly offset by substantially equal angular amounts about said axis to produce a web which is substantially balanced about said axis and in which said interstices are distributed substantially uniformly angularly about said axis.

7. A reinforced molded abrasive wheel as set forth in claim 6 wherein each of said oblong eccentric loops is of greater curvature at those portions thereof which are radially innermost and outermost than elsewhere, whereby said offset loops are overlapped more closely near the radially innermost and outermost positions thereof than elsewhere.

8. A reinforced molded abrasive wheel as set forth in claim 7 wherein said wheel has a central hub opening of relatively large diameter when compared with the outer diameter thereof, and wherein said radially innermost greater curvature of said oblong loops corresponds substantially to the curvature of said hub opening, whereby each of said loops produces a relatively large wrap-around near said hub opening to reinforce said body more strongly near said hub opening.

9. A reinforced molded abrasive wheel as set forth in claim 6 wherein said ribbon of said loops is oriented in inclined relationship to said axis within said body, and wherein said web is substantially planar.



10. A reinforced molded abrasive wheel as set forth in claim 6 wherein at least one end of said substantially continuous wound ribbon extends outwardly of said body.

11. A reinforced molded abrasive wheel as set forth in claim 6 wherein said means bonding said filaments together comprises a cured coating of resin on said filaments, said cured coating being compatible with and bonded with said binder material for said abrasive particles.

12. A reinforced molded abrasive wheel as set forth in claim 11 wherein filaments are substantially continuous glass filaments.

13. A reinforced molded abrasive wheel as set forth in claim 6 wherein each of said oblong loops is polygonal, with the substantially flat sides of each of said polygonal loops forming obtuse angles at each of said cross-over sites.

14. A reinforced molded abrasive wheel comprising a substantially annular body of abrasive particles secured together by binder material, at least one reinforcement web embedded within said body and including a substantially continuous band made up of substantially continuous high-tensile-strength filaments wound into a plurality of like full oblong generally circular loops which are angularly offset and are eccentric in relation to the axis of rotation of the wheel, said band being wound substantially in a path corresponding to that of a first point revolving at a substantially constant distance around a second point which in turn is revolving about said axis substantially mid way radially of said annular body, with the rotational period of the first point being only slightly shorter than that of the second point, filaments of each of said offset loops being overlapped and mingled with filaments of the other of said loops at a plurality of cross-over sites and leaving interstices between the offset crossed-over loops, said interstices being filled with said abrasive particles and binder material, and means securely bonding together the filaments of said loops at said cross-over sites.

15. A reinforced molded abrasive wheel as set forth in claim 14 wherein said substantially constant distance in slightly less than half of the radial thickness of said annular body, and wherein said bonding means comprises a substantially continuous cured coating of resin along said filaments.

16. A reinforcement web for molded articles rotatable about a center, comprising a substantially continuous band made up of a plurality of substantially continuous high-tensile-strength filaments and wound into a plurality of substantially circular full loops which are angularly offset by substantially equal amounts about the center and are eccentric in relation to said center, filaments of each of said offset loops being overlapped and mingled with filaments of the other of said loops at a plurality of the cross-over sites where the loops overlap, and means bonding together the filaments of said loops at a plurality of said cross-over sites.

17. A reinforcement web for a molded abrasive wheel rotatable about an axis, comprising a substantially continuous band made up of a plurality of substantially continuous high-tensile-strength filaments coated with resin and wound into a plurality of substantially full circular loops which are angularly offset by substantially equal amounts about said axis and are eccentric in relation to said axis, resin-coated filaments of each of said offset loops being overlapped and mingled with filaments of the other of said loops at a plurality of the cross-over sites, and said resin being cured to stiffen said web and to bond together the filaments of said loops at said cross-over sites.

18. A reinforcement web as set forth in claim 17 wherein said substantially circular loops are of like oblong configuration and size, and wherein each of said oblong eccentric loops is of greater curvature at those portions thereof which are radially innermost and radially outermost than elsewhere, whereby said offset loops are over-

lapped more closely near the radially innermost and outermost positions than elsewhere.

19. A reinforcement web as set forth in claim 18 wherein said web is substantially annular and has a relatively large central and substantially circular opening, and wherein said radially innermost greater curvature of said oblong loops corresponds substantially to the curvature of said circular opening, whereby each of said loops produces a relatively large wrap-around near said opening.

20. A reinforcement web as set forth in claim 17 wherein said band comprises a substantially continuous and flat ribbon of said filaments, and wherein said ribbon is oriented in inclined relationship to said axis.

21. A reinforcement web as set forth in claim 20 wherein each of said loops is polygonal, with the substantially flat sides of each of said polygonal loops forming obtuse angles at each of said cross-over sites.

22. A reinforcement web for a molded abrasive wheel rotatable about an axis, comprising a substantially continuous band made up of a plurality of substantially continuous high-tensile-strength filaments wound into a plurality of like full oblong generally circular loops which are angularly offset and are eccentric in relation to said axis, said band being wound substantially in a path corresponding to that of a first point revolving at a first substantially constant distance around a second point which in turn is revolving about said axis at a second substantially constant distance, with the rotational period of the first point being only slightly shorter than that of the second point, filaments of each of said offset loops being overlapped and mingled with filaments of the other of said loops at a plurality of cross-over sites and leaving interstices between the offset crossed-over loops, said interstices being distributed substantially symmetrically and uniformly around said axis, and means securely bonding together the filaments of said loops at said cross-over sites.

23. A reinforcement web as set forth in claim 22 wherein said first substantially constant distance is less than said second substantially constant distance, and wherein said bonding means comprises a substantially continuous cured coating of resin along said filaments which stiffens said web and securely bonds said filaments at said cross-over sites.

24. A reinforcement web as set forth in claim 23 wherein said filaments comprise substantially continuous glass filaments, and wherein said coating of resin protects said glass filaments from crushing by abrasive particles under molding pressures.

25. The method of forming a reinforcement web for molded articles rotatable about a center, which comprises winding a substantially continuous band made up of a plurality of high-tensile-strength filaments into a plurality of substantially circular full loops in symmetrical angularly-offset and eccentric relationship about the center while over-lapping and mingling filaments of each of the loops with filaments of other of the loops at a plurality of cross-over sites, and bonding the filaments of said loops together at a plurality of the cross-over sites.

26. The method of forming a reinforcement web for a molded abrasive wheel rotatable about an axis, which comprises coating a substantially continuous band made up of a plurality of high-tensile-strength filaments with an uncured resin in fluid form, winding the coated band while uncured into a plurality of substantially full circular loops in symmetrical angularly-offset and eccentric relationship about said axis while overlapping and mingling resin-coated filaments of each of the loops with filaments of other of the loops at a plurality of cross-over sites, and curing the resin to form a stiff web wherein the filaments are securely bonded together at the cross-over sites.

27. The method of forming a reinforcement web as set forth in claim 26 wherein said winding comprises winding the loops of said coated band in an oblong configuration of the same size and imparting a greater curvature to said loops at those portions of the loops which are radially innermost and radially outermost than elsewhere.

28. The method of forming a reinforcement web as set forth in claim 27 wherein said winding comprises winding said band around a relatively large and substantially circular central area, and imparting to said loops as said greater curvature the substantially circular curvature of said central area.



29. The method of forming a reinforcement web as set forth in claim 26 wherein said winding comprises flattening said band to form a substantially continuous flat ribbon and winding said flat ribbon in inclined relationship to said axis.

30. The method of forming a reinforcement web as set forth in claim 29 wherein said winding comprises winding said ribbon into substantially circular loops in polygonal form, with obtuse angles between substantially flat sides of the polygonal loops at each of the cross-over sites.

31. The method of forming a reinforced molded abrasive wheel rotatable about an axis, which comprises winding a substantially continuous band made up of a plurality of substantially continuous high-tensile-strength filaments into a plurality of like full oblong loops in symmetrical angularly-offset and eccentric relationship about said axis by winding said band substantially in a path corresponding to that of a first point revolving at a first substantially constant distance around a second point which is revolving about said axis at a second substantially constant distance, while maintaining the rotational period of the first point only slightly shorter than that of the second point, overlapping and mingling filaments of each of the offset loops with filaments of the other of said loops at a plurality of cross-over sites while leaving interstices between the offset loops which are distributed substantially symmetrically and uniformly around said axis, and securely bonding together the filaments of the loops at the cross-over sites.

32. The method of forming a reinforced molded abrasive wheel as set forth in claim 31 wherein said winding comprises maintaining said first distance less than said second distance, and wherein said bonding comprises applying a substantially continuous coating of resin along the filaments and curing the resin coating to stiffen the web and securely bond the filaments at the cross-over sites.

33. The method of forming a reinforced molded abrasive wheel as set forth in claim 32 which comprises molding a body of abrasive particles and a binding material therefor about the web after the resin coating is cured.

34. Apparatus for forming a reinforcement web for molded articles rotatable about an axis, comprising means supplying a substantially continuous band of high-tensile-strength material, a web-forming assembly having a center and including a plurality of guide means each having a plurality of band-supporting projections disposed for holding engagement with the material of said band, said projections of said assembly being arrayed about said assembly center to hold said band thereon in a pattern of substantially circular full loops which are symmetrically offset and eccentric in relation to the center and which are overlapped with others of said loops on said projections, and means for producing relative movements between said web-forming assembly and said band-supplying means for winding said band on said assembly in accordance with said pattern.

35. Apparatus for forming a reinforcement web for molded articles as set forth in claim 34 wherein said projections of each of said guide means are mounted at different radial distances from said center along a different radial path, and wherein the radial paths of said guide means are spaced substantially equiangularly about said center.

36. Apparatus for forming a reinforcement web for molded articles rotatable about an axis, comprising means supplying a substantially continuous band of high-tensile-strength material, a web-forming assembly having a center and means for collecting said band thereon, and means producing relative movements between said web-forming assembly and said supplying means which wind said band

on said assembly substantially along a path corresponding to the rotation of a first point at a first substantially fixed distance from a second point rotated about said center at a second substantially fixed distance and at a rotational period which is only slightly longer than that of said first point.

**37.** Apparatus for forming a reinforcement web as set forth in claim **36** wherein said supplying means further comprises means applying a bonding material to said band in liquid form.

**38.** Apparatus for forming a reinforcement web for a molded abrasive wheel rotatable about an axis, comprising means supplying a substantially continuous band made up of a plurality of substantially continuous filaments, a web-forming assembly including plate means, means for mounting said plate means for rotation about a center point, a plurality of radially extending guide means mounted on said plate means each at a different angular position about said center, each of said guide means having a plurality of band-supporting projections each disposed to engage and hold the material of said band at a different radial distance from said center, said band-supporting projections of said different guide means being disposed relative to one another on said plate means to hold said band of filaments thereon in a pattern of substantially circular loops which are symmetrically offset and eccentric in relation to said center and which are overlapped with other of said loops on said projections.

**39.** Apparatus for forming a reinforcement web for a molded abrasive wheel as set forth in claim **38** wherein the radially innermost and outermost of said projections of all of said guide means are respectively at substantially the same radial distances from said center, and wherein corresponding projections of angularly alternate ones of said guide means intermediate said innermost and outermost projections are staggered at different radial distances from said center, said projections of said guide means lying substantially along a path corresponding to the rotation of a first point at a first substantially fixed distance from a second point rotated about said center at a second substantially fixed distance and at a rotational period which is only slightly longer than that of said first point.

**40.** Apparatus for forming a reinforcement web for a molded abrasive wheel as set forth in claim **39** wherein said first distance is shorter than said second distance.

**41.** Apparatus for forming a reinforcement web for a



molded abrasive wheel as set forth in claim **40** wherein said plate means comprises a back plate, means mounting said guide means and projections on said back plate, a faceplate having openings therein for said projections to extend therethrough, and means for separably fastening said back plate and faceplate together.

**42.** Apparatus for forming a reinforcement web for a molded abrasive wheel as set forth in claim **41** wherein each of said guide means comprises an elongated guide member having slots thereinforming said projections, and further comprising means mounting said guide members on said back plate for radial sliding movements thereon, said openings in said faceplate being in the form of substantially radial slots accommodating the slotted guide members therein, and a substantially circular camming member mounted for movement axially toward and away from said back plate, the periphery of said camming member being disposed to engage said guide members and force them radially outwardly simultaneously when said camming member is moved axially toward said back plate.

**43.** Apparatus for forming a reinforcement web for a molded abrasive wheel as set forth in claim **42** further comprising spring means resiliently urging all of said guide members radially inwardly toward said axis.

**44.** Apparatus for forming a reinforcement web for a molded abrasive wheel as set forth in claim **43** wherein said slots are inclined toward said center in direction away from said faceplate and toward said back plate, wherein said periphery of said camming member is inclined toward said axis in direction away from said faceplate, and further comprising means mounting said camming member on said faceplate centrally thereof.

**45.** Apparatus for forming a reinforcement web for a molded abrasive article as set forth in claim **39** wherein said band supplying means includes an open-topped container for a bonding material in liquid form, and means guiding said band through the material in said container.

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ROBERT C. RIORDON, *Primary Examiner.*

L. SELMAN, *Assistant Examiner.*