

June 30, 1953

J. R. ERICKSON
GRINDING WHEEL

2,643,494

Filed Aug. 25, 1952

2 Sheets-Sheet 1

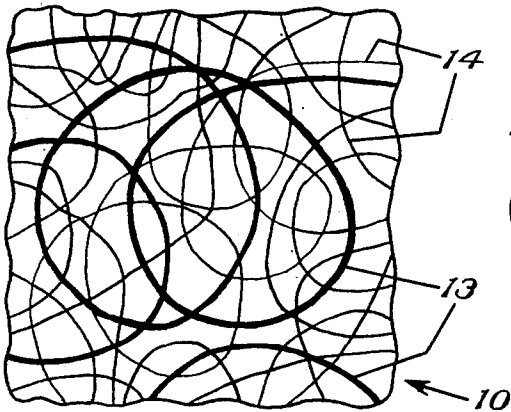


FIG. 1

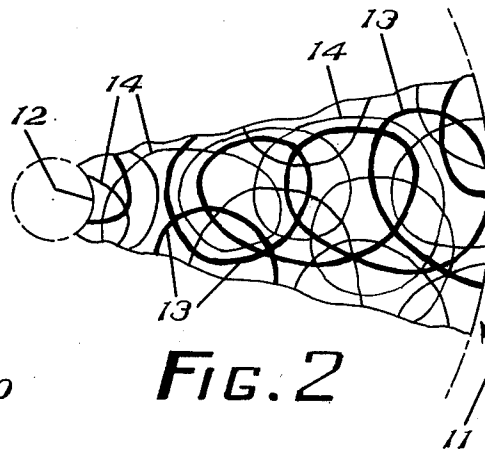


FIG. 2

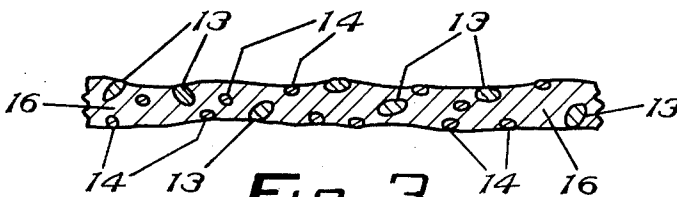


FIG. 3

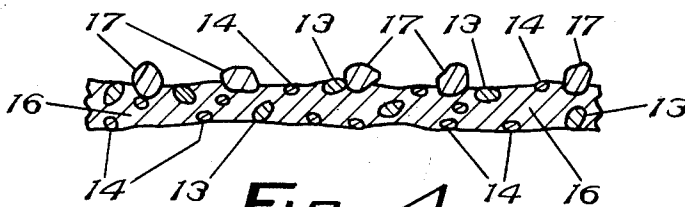


FIG. 4

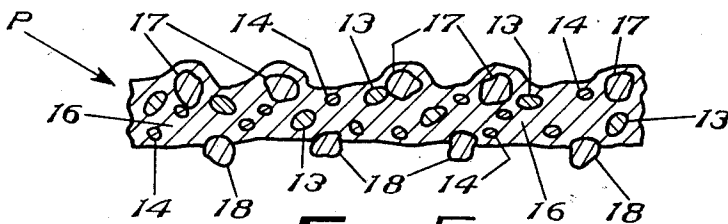


FIG. 5

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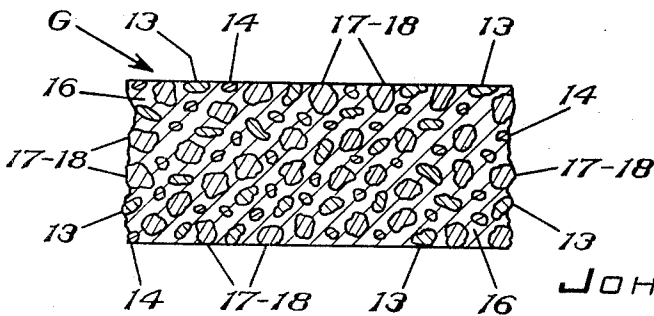
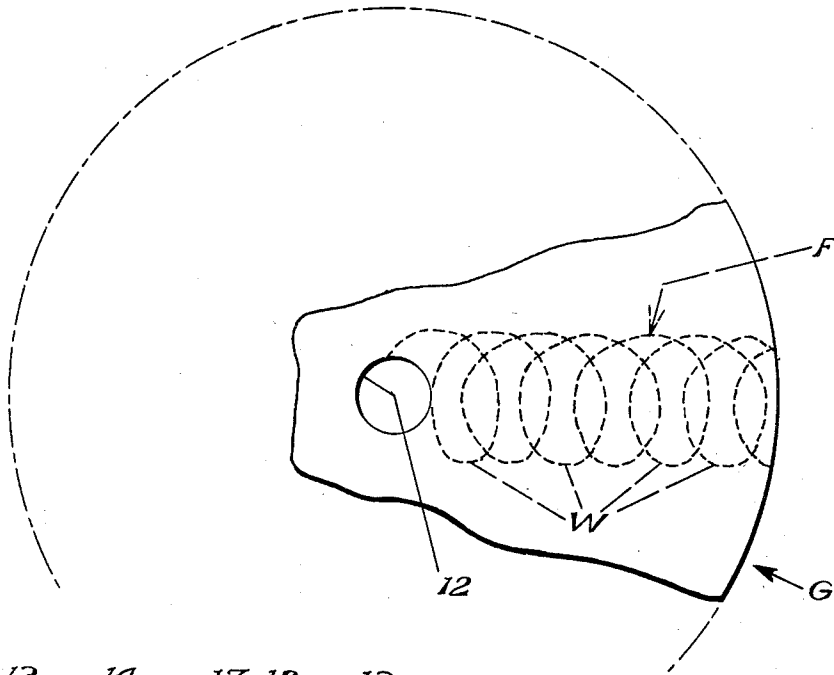
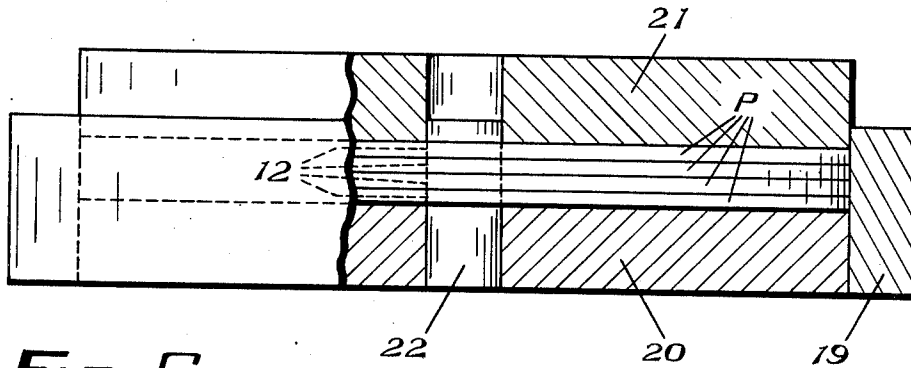
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2,643,494

GRINDING WHEEL

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Application August 25, 1952, Serial No. 306,111

6 Claims. (Cl. 51—206)

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This invention relates to thin grinding wheels.

One of the objects of this invention is to provide a construction for a grinding wheel of the relatively thin-disc peripherally operative type that will be stiff and rigid but not brittle, and well adapted for and capable of withstanding side or lateral thrusts, pressures, blows and the like to which it may be subjected in practice, particularly when used as part of a motor-driven hand tool or grinder where the operator utilizes the weight of the motor-unit and manually applied force to press the wheel against the work oftentimes with the plane of the wheel at only a small angle to the surface of the workpiece. A typical use in this manner is in the grinding away of tough and hard and irregular projections or protuberances that result from welding metal parts, such as steel parts, heavy sheet steel (as in automobile fabrication, including bodies of welded-together steel plate, and the like. Or, by way of further illustration, such a hand-grinder may be used as a cutting-off wheel, for example, to cut off gates and risers in castings; in such use it is frequently subjected to severe and sudden twisting strains and stresses.

Another object is to provide a grinding wheel construction of the above-mentioned character that effectively interrelates structural elements and abrasive grain for high surface speed and for efficient cutting action and for great strength and ruggedness to resist breakage under the varying exigencies of practical use, use which is oftentimes inherently abusive because of the nature of the workpiece as well as sometimes inadvertently or necessarily severe in its mechanical reactions on the relatively thin wheel.

Another object is to provide a grinding wheel of the above nature and a method of making it in which many continuous glass fibers may be utilized and a desirable avoidance of structural striations of abrasive grain and internal structural elements may be achieved in a practical, efficient and economical manner, and by which improved cutting efficiency, better strength and ruggedness and safe operation at effectively high surface speeds may be achieved.

Another object is to provide a grinding wheel of the above nature and a method of making it in which, by unique interrelationships of abrasive grain, bond, and glass filaments or fiber of great or continuous lengths, manufacturing, structural and functional advantages may be achieved that are markedly superior to known practices and grinding wheel structures.

Another object is to provide a grinding wheel of the above nature and a method of making it in which glass filaments or fibers of substantial or great lengths and abrasive grain and bond are physically interrelated, with the long lengths of glass elements distributed substantially uniformly in continuous overlapping whorls of rela-

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tively large diameter, to provide for facility of manufacture and to provide, in the grinding wheel, a distribution of grain and bond and convoluted glass filaments that makes for great and uniform strength and rigidity with facility for strain without fracture under the conditions of practical use and that provides uniform and substantially free cutting throughout its peripheral relatively narrow face (which may be beveled). Moreover, it is an object of this invention to carry out this last-mentioned object in a manner which, for manufacturing and ultimate structural advantages, permits building up of the wheel in what, in the process of making it, may be called layers or plies, whereby to facilitate and economize in the manufacture of wheels of different ultimate thicknesses, but which layers or plies do not appear in the finished grinding wheel which, in its cross-section and at its peripheral grinding face, is substantially devoid of striation, laminae, strata, or the like and is thus capable of superior and faster cutting action.

Other objects are to provide an improved thin-disc peripherally-operative grinding wheel and an improved method of making it; other objects will be in part obvious or in part pointed out hereinafter.

The invention accordingly consists in the features of construction, combinations of elements, arrangements of parts and in the several steps and relation and order of each of the same to one or more of the others thereof, all as will be illustratively described herein, and the scope of the application of which will be indicated in the following claims.

In the accompanying drawings, in which is shown illustratively a preferred embodiment of the mechanical features of my invention and in which similar reference characters refer to similar parts throughout the several views,

Figure 1 is a fragmentary plan or elevational view of a whorled-glass-strand mat, indicating geometric conformations and relative dispositions of the swirled glass fibers thereof without intending or attempting to show all of them;

Figure 2 is a similar view of a disc-like element died out of the mat of Figure 1;

Figure 3 is a large-scale fragmentary cross-sectional view, which may be considered as taken anywhere through the died-out disc element of Figure 2, showing and indicating certain relationships of the parts after one step of treatment of the died-out disc of Figure 2;

Figures 4 and 5 are views like that of Figure 3, indicating structural relationships, with the addition of abrasive grains, resulting from certain succeeding steps;

Figure 6 is a front elevation of a mold and of a number of prefabricated grinding wheel components therein, ready to be subjected to heat and pressure, with certain of the mold parts

broken away along a transverse diametrical plane or section;

Figure 7 is a fragmentary elevational view of the final grinding wheel, and

Figure 8 is a large-scale transverse section of the wheel of Figure 7 and which may be considered as taken anywhere transversely through the grinding wheel, indicating certain structural relationships of the grinding wheel elements without, however, intending or attempting mathematical accuracy in numbers of grains and glass fibers shown.

In practicing my invention, I first provide a whorled-glass-strand mat 10 (Figure 1) about to be described and which can be obtained in large sheets or rolls, and from it I die out a suitable number of discs 11 (Figure 2) of the desired diameter, for example, 9 inches for a 9" diameter grinding wheel and at the same time die out a center hole 12 of the desired diameter illustratively $\frac{7}{8}$ " in diameter. Mat 10 is made of many very long single and also stranded glass fibers which are not interwoven or otherwise interlocked in a regular pattern, as are woven or textile cloth, or felts, or the like, but in the main each is in the form of many continuous or connected whorls or convolutions or complete turns of substantial radius, for example, a radius on the order of $\frac{3}{4}$ of an inch with the centers of the continuous connected turns displaced along various shapes of paths throughout the area of the mat and with the turns lying substantially all in a substantially flat plane; thus, successive turns or whorls of any one glass fiber or thread overlap each other and they, in turn, are overlapped by and may be interleaved with similarly displaced turns of other long glass fibers or threads, some being single and others being stranded, that is, the latter comprise two or more glass filaments twisted together. In Figures 1 and 2, this structure, which is somewhat difficult to illustrate in drawings, is indicated, the heavier whorls 13 being stranded glass fibers and the lighter whorls or turns 14 being those of single glass filaments. The whorls which are of relatively large radius or diameter (illustratively a diameter of around $1\frac{1}{2}$ inches) though the radii of the whorls of all of the glass filaments need not be the same and may differ variously and which overlap each other and are in effect interleaved with each other, are made of such numbers of individual fibers that are continuous or of great length as to leave many interstices or openings throughout the mat which are irregularly polygonal in shape with the sides formed by arcuate or curved portions of three or more glass fibers, single or stranded, such portions being parts of intersecting or crossing complete whorls or turns above described. The sizes of the openings are not necessarily uniform, for it will now be apparent that they can vary widely, depending upon the closeness of overlap of whorls or turns, relative radii of the latter, and the number of whorled fibers that are laid one upon the other with or without their turns or whorls interleaved. The fibers are of great length, each providing many lapped whorls. A mat which has overlying lapped whorls or convolutions, of radii on the order of $\frac{3}{4}$ of an inch, made of a sufficient number of glass fibers, both single and stranded to give an average thickness of about $\frac{1}{2}$ of an inch and with scattered and numerous openings of which the largest has a diagonal dimension on the order of $\frac{1}{8}$ of an inch or so, gives good results.

The lapped individually convoluted or whorled glass fibers, single or stranded or both, of the mat may, in course of manufacture of the mat, be thinly coated with a suitable material such as urea-formaldehyde latex binder, to provide a bond or adhering together between the fibers where they cross each other; other usable binder materials may be phenol formaldehyde resin, polystyrene and the like. The number of crossing of each whorl by others is, of course, large, and these bonds at the crossings not only help to keep the lapped convolutions in lapped relation and against relative shifting but also aid to more or less anchor or secure each complete whorl or turn, at many points, to other whorls, and thus all are held against material distortion out of their respective generally circular shapes. As a result, the mat, while very flimsy in appearance and extremely pervious (one can literally see through it and in that sense it is transparent) has sufficient "body" or intactness so that it can be handled without material disturbance of its lapped convoluted structure and it can be easily cut or died out, as above described, without detrimental fraying along its cut edge, even though, at the cut, the free ends of the cut fibers are directed in many directions as a result of cutting across a great many lapped whorls of the fibers. Because of these lapped whorls, and the many interstices, the respective sides or faces of the mat are not surfaces in the geometric sense, nor are they smooth or unbroken though they are in effect flat. Where stranded fibers are employed, the twist of the glass filaments thereof is relatively slight and of very large pitch, the stranded fiber appearing somewhat like a narrow ribbon with the glass filaments thereof more or less side by side and held together by the above-mentioned binder; these stranded fibers may, therefore, have a cross-section that is somewhat flattened out or elongated, and in the drawings about to be described this elongated or flattened cross-section of the stranded fibers is suggested, not necessarily to scale, to indicate that stranded glass fibers may be embodied in the mat along with single-filament strands or fibers which are shown in smaller cross-section, more or less uniform in cross-section and illustratively circular. The mat above described is a product of Owens-Corning Fiberglass Corporation and is known as "Fiberglas Swirled-Strand Mat, No. 504."

Having died out a sufficient number of discs 11, I apply to the lapped convoluted fibers of the discs a suitable organic bond, illustratively and preferably a liquid water-miscible phenol formaldehyde resin such as Bakelite resin QBR 11857, which as available on the market is 56% of solids with the rest water, though it is preferred to thin it by the addition of water so that it is about 48% of solids.

These proportions are not critical in that variations may be effected according to the method used for coating the peculiar filament structure of the lapped-whorled glass fiber disc; the 48% of solids proportion is found suitable where a roller-type of coating machine is used, in which the disc is run through between two opposed rollers which apply the liquid resin thereto. This coating operation is easily carried on, the machine comprising essentially two opposed steel rolls, of known type. In the coating process it is the individual convoluted glass fibers that are thoroughly coated because of the open-work character of the fiber mat structure, but also

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the disc as a whole is in effect coated in that all or at least most of the apertures or interstices or variably-shaped polygonal openings there-through are in effect closed or bridged over by a sort of film of resin, and such as are not so closed completely become closed in a repetitive coating step later described.

In Figure 3 is indicated in somewhat exaggerated and diagrammatic form a fragmentary cross-section of the resultant structure; it is not to scale, and it is not intended to show all the fibers in a cross-section of the coated disc. It is, however, intended to show in Figure 3 the general relationships of the structural elements involved. For example, it shows cross-sections of the fibers, some of larger cross-section than others; the former are the stranded glass fibers 13, and the latter are the single-filament glass fibers 14. Some of these fiber cross-sections are circular, while others are in varying degrees oval, indicating the many different angles at which the whorled fibers are intersected by the plane at which the cross-section is taken. The resin coating is indicated at 16; it envelops individual glass fibers and fills in and bridges over the many gaps or interstices between fibers; the larger the gap or aperture through the whorled fiber structure, the thinner is the resin that stretches across it to bridge it or close it. Because there may be more fibers at one point of the cross-section than at another, or because some of the apertures of the open-work disc are smaller than others and vary widely in size and shape, the resin 16 appears and is of varying thickness, as is suggested or intended to be indicated in Figure 3, and the same is true, of course, of the coated disc structure.

On one side of the thus coated and undried disc I now apply, as by sprinkling, reasonably uniformly, abrasive grains which become adhered to the resin, and the individual grains are thus held in position, substantially uniformly distributed throughout the area of that side of the disc; the quantity of grain used is preferably materially less than is needed to make up a single layer of grains so that grains are spaced from each other. The abrasive grains appear as that many uncrowded projections from the surface of the resin, though some or all may to some extent extend into the resin itself. Many of the grains are located and held over or in line with gaps or interstices in the fiber open-work. In Figure 4 is shown a replica of Figure 3, but showing the abrasive grain 17 distributed throughout in exaggerated spaced relation and adhered to the upper side of the coated fiber disc.

Illustratively, the grain 17 may comprise No. 24 grit size of aluminum oxide abrasive grain, of which, for a 9" diameter resin-coated whorled glass fiber blank with a $\frac{1}{8}$ " hole at the center, about 20 grams is distributed throughout the one side face above mentioned. Resin-coated abrasive grains may be used, particularly where quicker or better adherence of the grains to the resin 16, during the process step of distributing the grain thereto, is desired, and any suitable or known coated abrasive may be employed. As an illustration, I may prepare such coated grain, illustratively in the case of the above No. 24 grit size grain, by plasticizing or wetting the grain with a liquid phenol formaldehyde resin such as Bakelite BR 9332 and mixing into the plasticized grain a powdered phenol formaldehyde resin such as Bakelite BR 2417, which thus becomes

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distributed about and adhered to the surfaces of the grains; illustrative proportions to provide such better adhering grains may be about 83% by weight of No. 24 grit size grain, about 5% by weight of BR 9332 and about 12% by weight of BR 2417. Of this dry granular mix, I spread or uniformly distribute onto the resin-impregnated glass fiber open-work (9" in diameter) about 20 grams.

In either case a somewhat sparse distribution of grains throughout the area results. The grains, in this illustration, are not crowded and spacings between them may be on the order of several times the average maximum dimension of the grains themselves. The density of distribution of the grains may, of course, be widely varied for any particular grit size of grain employed, according to the particular grinding action desired in the final wheel.

Because of the many interstices bridged over by resin webs or films, many, if not most, of the grains are held thereby in or over the many apertures, gaps or interstices formed by the lapped glass fiber whorls. Principally because of a similar distribution of such grains to the other face or side, as is presently to be described, it may be said, in this illustration utilizing No. 24 grit size of grain, that for this order of magnitude of grain size and larger the grains distributed to each side can be materially less in number than the apparent interstices in the open-work fiber structure.

With grain applied to one side of the disc-like structure, the latter is now dried to set the adherence of the applied grains; this may be done at a temperature of about 110° C. for about 10 minutes. Thereupon it is again coated with liquid resin as above described, as by running the disc through the opposed rollers of the coating machine, and a similar quantity of abrasive grain is then applied and again relatively sparsely, in the case of No. 24 grit size grain, distributed uniformly onto the other side, and the disc-like structure is dried to set the adherence of the applied grains; this step of drying may be done at a temperature of about 110° C. for about 25 minutes. The resultant structure is indicated in Figure 5, designated as a whole by the reference character P; Figure 5 is a replica of Figure 4 except that it shows the added abrasive grains 17 and a somewhat increased thickness of the resin 16, resulting from the just-described steps. Though the grains are held, like so many projections from the surface of the resin, on both sides of the structure, a great many of them are anchored in stretches or webs of resin that bridge or close over interstices as above described; the open-work provided by the lapped whorled glass fiber structure is per se so replete with scattered apertures of varying sizes and shapes as to provide, when the resin is applied thereto, a large number of bridges of resin in and by which to hold and secure grains in or over such gaps or apertures. With smaller grit size of grains, more grains may be so held and secured, and vice versa.

The structure P of Figure 5 may be produced in quantity, and a sufficient number of them is used in making a grinding wheel, depending upon the required thickness of the latter.

For example, to make a grinding wheel of a thickness on the order of $\frac{1}{8}$ of an inch, say 0.160" thick, four such disc-like structures P of Figure 5 will suffice; they are stacked one upon the other, coaxially, in a suitable mold for subjecting them to heat and pressure. In Fig-

ure 6 is indicated a type of steel mold that may be used. It comprises a cylindrical mold band 19, a bottom plate 20, a top plate 21 and an arbor 22 which coacts with the several parts in maintaining coaxiality and which extends through the holes 12 in the disc structures P so as to properly and coaxially shape the center hole of the ultimate grinding wheel. For simplicity of illustration the parts P are shown in front elevation; the final grinding wheel, however, is homogeneous throughout and if parts P existed as layers, or strata, each with its own open-work of glass fiber, they disappear as such in the final wheel.

The stacked disc structures P in the mold are now subjected to pressure of about $\frac{1}{4}$ of a ton per square inch for 15 minutes at a temperature of about 160° C. The dried resin 15 (Figure 5), which carries the grains externally of the stacked members P, becomes mobile under heat and pressure, and abrasive grains, such as grains 17 and 18 (which are in effect only surface-carried by parts P) are in the main substantially moved and shifted inwardly of and inbetween the whorled fiber open-work; in general, they are displaced in varying degrees, inwardly (that is, in upward and downward directions, as seen in Figure 6) of each of what was initially a part P, and most, if not all, of them are entered directly into the spaces or interstices between the manifold lapped whorled glass fibers, while the whorled fiber structures 11 (Figure 2) of the parts P virtually bodily approach each other, which they can do because they are so open in structure that individual whorls or parts thereof can bypass or be bypassed by, more or less, some of the grains as the latter in effect enter into the gaps or interstices. Moreover, this relative bypassing between whorls and grains results in minimum, if any material or consequential, shearing strains or action on the glass fiber whorls, and the latter are subjected to minimum, if any, mechanical weakening.

The step of heat treatment under pressure is not simply a compacting in an axial direction; while the over-all thickness of the stacked parts P is in the process reduced to about 0.160", such shifts of elements, substantially as described above, have taken place as result in quite different relationships therebetween from what existed in the parts P individually and in the stacked parts P in the mold, whatever number of parts P that is needed to give a grinding wheel of the desired thickness. Where the elements of the parts P as initially stacked in the mold are literally in layers or plies or strata, each being in effect per se striated, in the pressed and cured grinding wheel there is no material stratification and, instead, there is homogeneity; the lapped convoluted glass fiber structures 11 (Figure 2) of the several parts P are virtually brought flatwise, as it were, together without any material or discernible line or plane of demarcation, and moved into interspersed and uniformly distributed relation throughout the many resultant whorls are the abrasive grains, all (both the continuous whorls and the grains) embedded in and bonded together by the cured resin bond. The grinding wheel is shown at G in Figure 7, and in Figure 8 is a fragmentary large-scale sectional view in which, in general and in perhaps exaggerated form, the above described relationship of homogeneity is intended to be indicated, without, however, attempting to indicate exact volume of resin, or exact numbers of grains.

fibers or whorls of fibers, or exact relative proportions therebetween.

These latter factors are variable, as will now be understood; size and quantity of grains, amount of organic bond (variable by the "coating" process or according to the number of repeated coating steps), diameter or thickness of the glass filaments of mat 10, radius or relative radii of the whorls or convolutions, thickness of the initial mat 10 employed, and pressure and temperature in the mold applied to the stacked parts P, may be varied individually or any one or more in relation to any one or more of the rest, according to the ultimate characteristics desired for the final grinding wheel, all as will now, in view of the foregoing, be understood by those skilled in the art.

The grinding wheel and method of making it achieve the objects above noted and many advantages. The grinding wheel has superior strength and resistance against detrimental or fracturing deformation out of its plane, as, for example, when the workman presses its periphery, which may be beveled, with great force against the work with the plane of the grinding wheel at a very small angle to the plane or run of the work-piece, such as welded sheet steel. Such stresses tend to dish or bow the grinding wheel, at least such sector thereof as is peripherally operative upon the work, but the wheel, even though relatively thin, illustratively on the order of $\frac{1}{8}$ of an inch thick or so, does not break; bearing in mind the above described homogeneity which, of course, includes a substantially uniform distribution of lapped whorls of glass fibers in each of many planes between, and parallel to, the opposed side faces of the grinding wheel, all of the whorls being solidly and continuously embedded and anchored in the organic bond, stresses that tend to dish the wheel or a portion thereof tend to put in tension those relatively connected and continuous whorls that are at or adjacent to the convexed side face of the grinding wheel and tend to put in compression those whorls that are at or adjacent to the concaved side face of the grinding wheel. These whorls, however, are like hoops or rings, of relatively large diameter, and they resist change in their effective diameters somewhat like a ring or hoop holds against increase or decrease in its diameter. Accordingly, even though, under a particularly great stress or force, the cured resin or other organic bond strains or tends to strain, such tendency to strain is effectively opposed by the great many continuous and connected loops or whorls of the glass fiber, the loops or whorls and the bond co-acting to give superior strength against fracturing, cracking or breaking of the wheel.

These and later described coactions may be better understood by reference to Figure 7, in which I have indicated in broken lines and by way of example the lapped whorls or turns W of one glass fiber F, which may be single, like the single-filament glass fibers 14, or stranded, like the glass fibers 13 above described in connection with Figures 1-5. They are like a flattened-out helix with the successive turns or loops thereof lapped as above described, and though the single fiber F selected for illustration in Figure 7 is shown as having its lapped whorls extend along a course or path which is substantially along a radius, it will be understood that that is but illustrative because, in the mat 10 of Figure 1 and in the cutout disc 11 of Figure 2, the courses or paths which the lapped whorls of the different

fibers take vary widely and they may criss-cross each other at various angles or may in and of themselves depart from a straight line and in fact the courses of some of them can be back and forth in one direction while the courses of others can be back and forth in transverse or angular directions relative thereto.

Whatever courses taken by the individual glass fibers that form these connected whorls, loops or convolutions W, the general planes of the latter, of whatever individual fiber they happen to form a part, are generally parallel to each other and at right angles to the axis of the grinding wheel, thus positioning the many relatively large-diametered whorls or convolutions W for coactions such as those above described when pressures or blows tend to dish the wheel and for coactions later described. The broken-line indication of the whorls W of one illustrative glass fiber F in Figure 7 helps to make clear how it is possible, by the illustrative method of construction above described, to get a very great number of these whorls or turns W substantially uniformly distributed throughout the circular area of the disc-like grinding wheel structure and also, by interactions of the elements of the parts P that take place in the mold (see Figure 6) as above described, to obtain substantially uniform distribution of whorls or turns W in the direction from one side face of the grinding wheel of Figure 7 to the other side face thereof.

Rotating at substantial speed, the structure of the wheel is subjected to substantial centrifugal forces which, as is known, are greater according as the radius and velocity are greater. They place the wheel structure in tension throughout, particularly the bond which tends to strain in directions generally outward and tending to increase the peripheral circumference. However, uniformly distributed throughout the structure are the above-described very many lapped glass fiber whorls or turns which lie in many planes between and generally parallel to the side faces of the wheel. The glass fibers of these hoop-like elements are of good tensile strength, and each loop or whorl, itself strongly bonded to and by the bond material throughout its length, is put in tension when the relatively rigid cured bond strains. As above described, the structure provides many thousands of these loops or whorls; they are relatively displaced from each other both radially and axially. Also, each is located so that its center (or center of curvature) is radially displaced from the axis of rotation of the wheel and accordingly each loop or whorl moves bodily in a circular orbit as the wheel rotates (see Figure 7). Considering each whorl as an individual body, it is as such subjected to some centrifugal force but its glass fiber is on that account subjected to far less, if any, stress than would be the case were the same length of fiber stretched out along a radius, and as a result each loop or whorl or convolution is better adapted to make its tensile strength available to act in opposition to strains or straining of the bond material which it encircles and which centrifugal forces cause to strain.

For such reasons as these, the grinding wheel has a superior factor of safety. For example and bearing in mind that the cutting speed of the grinding wheel is around 11,000 surface feet per minute, the wheel when subjected to a destructive centrifugal or speed test will not fracture or break until a speed of 33,000 S. F. P. M. or over is reached. For this type of grinding wheel, for

uses such as those mentioned in the objects above set forth, the highest recommended speed is 14,000 S. F. P. M.

In grinding action the wheel is efficient and free-cutting, and at its periphery, whether that is squared off or is beveled, it presents homogeneity throughout, there being uniform distribution of bond, abrasive grains, and cross-sections of glass fiber, and this characteristic is continuous and persists as the grinding wheel wears down in use and its radius becomes less and less. For example, a 9" disc grinding wheel may be operated until its periphery closely reaches the peripheries of the clamping washers or discs by which the grinding wheel is mounted in the apparatus, such as the motor-driven hand tool above mentioned, and thus its diameter may be reduced to about 4" or so. The free-cutting action of the grinding wheel likewise remains inherent as the wheel wears down and its radius is reduced, the uniformly distributed whorls of the glass fiber always presenting a round or oval cross-section of glass fiber at the peripheral cutting face, the fiber wearing away as bond and abrasive grain wear away or are lost as grinding proceeds.

These latter features of construction and action at the peripheral grinding face bear out the desirable absence or avoidance of striation or stratification mentioned above as contrasted with the detrimental grinding action of grinding wheels utilizing woven, felted, or other cloth of glass fiber where the glass cloth stratifies the wheel structure and presents, at the peripheral grinding face, complete and continuous peripheral rings, in definite planes spaced crosswise of the grinding wheel face, of the fibers of the glass textile material, presenting a multiple-frayed peripheral grinding wheel face at which the protruding glass fibers can materially interfere with the cutting action of the abrasive and with the necessary wearing away of the bond.

In mentioning, in the above illustration, that the abrasive grains are of aluminum oxide, that is of course to be understood as illustrative, for other kinds or types of abrasive grain may be used, of which it will suffice to mention, as illustration, silicon carbide, emery, garnet, or even diamonds. So, also, with respect to the phenol formaldehyde resin set forth in the above-described illustrated embodiment as an illustration of an organic bond, of which there are many others that may be used, such as various other resins or resinous or curable plastic compounds, as well as natural rubber and synthetic rubbers or elastomers, as will now, in view of all of the foregoing, be understood by those skilled in the art.

It will thus be seen that there has been provided in this invention a grinding wheel and a method of making it, in which the various objects hereinabove set forth or indicated, together with many thoroughly practical advantages, are successfully achieved.

As many possible embodiments may be made of the mechanical features of the above invention and as the art herein described might be varied in various parts, all without departing from the scope of the invention, it is to be understood that all matter hereinabove set forth, or shown in the accompanying drawings, is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A grinding wheel comprising a relatively

thin disc-like structure presenting a peripheral grinding face which is homogeneous throughout and which continues to be homogeneous as the grinding wheel wears down toward its center, said structure comprising many long glass fibers each of which is conformed into many connected or continuous whorls in lapped relation to each other and to the lapped whorls of other fibers, with the planes of the whorls of the many whorled fibers extending in many planes generally parallel to and between the opposed side faces of the disc-like structure, the radii of the whorls being materially less than the effective radius of the grinding wheel so that, along any radius of the grinding wheel, there extend many lapped glass fiber whorls with the glass fibers of the radially-outermost whorls cut off and terminated at said peripheral face, abrasive grains substantially uniformly distributed throughout and amongst the multitudinous spaces provided by and amongst the lapped whorls, and an organic bond in which said many lapped whorls and said abrasive grains are embedded, said peripheral grinding face presenting, as it wears down, substantially uniformly distributed elements that comprise abrasive grains, cross-sections of glass fibers, and bond.

2. A grinding wheel comprising a relatively thin disc-like structure presenting a peripheral grinding face, said disc-like structure comprising many closed large-radii loops of glass fiber with the loops arranged in lapped relation to each other and with the planes of the loops extending in many planes generally parallel to and between the opposed side faces of the disc-like structure and thereby providing many interstices and spaces between and amongst the fibers of the loops, abrasive grains in interstices and spaces amongst the glass fibers of the lapped loops and substantially uniformly distributed throughout the volume of said disc-like structure, and an organic bond enveloping all of said lapped loops and all of said abrasive grains to fix the positions thereof relative to one another whereby tendency of the bond to strain under centrifugal forces is opposed by response, in tension, of the glass fibers of the loops to resist enlargement of the loops, the glass fibers of radially-outermost loops that intersect said peripheral grinding face terminating cross-sectionally in the latter, said peripheral grinding face presenting, as it wears down, substantially uniformly distributed elements that comprise abrasive grains, cross-sections of glass fibers, and bond.

3. A grinding wheel comprising a relatively thin disc-like structure presenting a peripheral grinding face, the mass of said disc-like structure comprising an organic bond having embedded therein and bonded in position thereby many long glass fibers each of which is convoluted to provide many connected turns, the planes of the turns of said convoluted fibers extending in many planes generally parallel to and between the opposed side faces of the disc-like structure and the centers of curvature of the turns of each convoluted glass fiber being displaced from each other whereby there are provided a large number of variegated three-dimensional spaces amongst the turns of said convoluted glass fiber which are occupied by the organic bond and by abrasive grains embedded in the latter.

4. A relatively thin disc-like grinding wheel presenting a peripheral grinding face, said grinding wheel comprising an unstriated disc-like structure of many long glass fibers conformed

into loop-like turns of relatively large radii, with the planes of the turns extending in many planes generally parallel to and between the opposed side faces of the disc-like structure and with the centers of curvature of the turns that lie more or less in any one plane displaced from each other to substantially uniformly distribute the turns, in overlying relation, throughout the circular area of the disc-like structure and an organic bond embedding all of the closed fiber turns and occupying the variegated spaces therebetween, said bond holding and anchoring abrasive grains substantially uniformly interspersed amongst said glass fiber turns.

5. An intermediate product in the form of a grinding wheel component comprising a disc-like open-work structure of many long glass fibers each of which is conformed into many connected whorls in lapped relation to each other and to the lapped whorls of other fibers with the planes of the whorls at right-angles to the axis of the disc-like structure whereby there are provided many substantially open spaces of variegated sizes and shapes, an uncured organic bond covering the glass fibers of all of said whorls and bridging and substantially closing over said many spaces of variegated sizes and shapes, and abrasive grains distributed throughout the face of said disc-like structure and held in position and secured against passage through said variegated spaces between the glass fiber whorls, by said uncured organic bond.

6. The steps in a method of making a grinding wheel that comprise applying an uncured organic bond in liquid form to a pervious disc-like structure that comprises long glass fibers each of which is conformed into many connected whorls in lapped relation to each other and to the lapped whorls of other fibers with the planes of the whorls of the many fibers extending at substantially right-angles to the axis of the disc-like structure, the uncured organic bond being embodied in amount sufficient to substantially bridge over the many open spaces of variegated shapes and sizes that exist because of said lapped glass fiber whorls, distributing abrasive grains onto the surface of the uncured organic bond to surface-hold the abrasive grains in distributed relation and against falling through said variegated spaces between the glass fiber whorls, heat-treating the resultant structure to dry the uncured organic bond and thereby set its surface-holding action on the distributed abrasive grains, thereby forming a grinding wheel intermediate component, stacking a plurality of such grinding wheel intermediate components one upon the other and coaxially within a mold, and in the mold subjecting the stack of components to heat and pressure to first mobilize the uncured bond of all of said components and under continued pressure to move abrasive grains into spaces between glass fiber whorls and to bring the whorled open-work glass fiber disc-like structures of all of said components into substantial engagement with each other and thereby substantially uniformly distribute the whorls thereof in many planes generally parallel to and between the opposed side faces of the resultant unified entity, and upon curing of the organic bond removing the unitary grinding wheel structure from the mold.

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No references cited.