Feb. 6, 1951 G. J. GOEPFERT ET AL 2,540,112

ABRASIVE WHEEL

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Fig. 1.

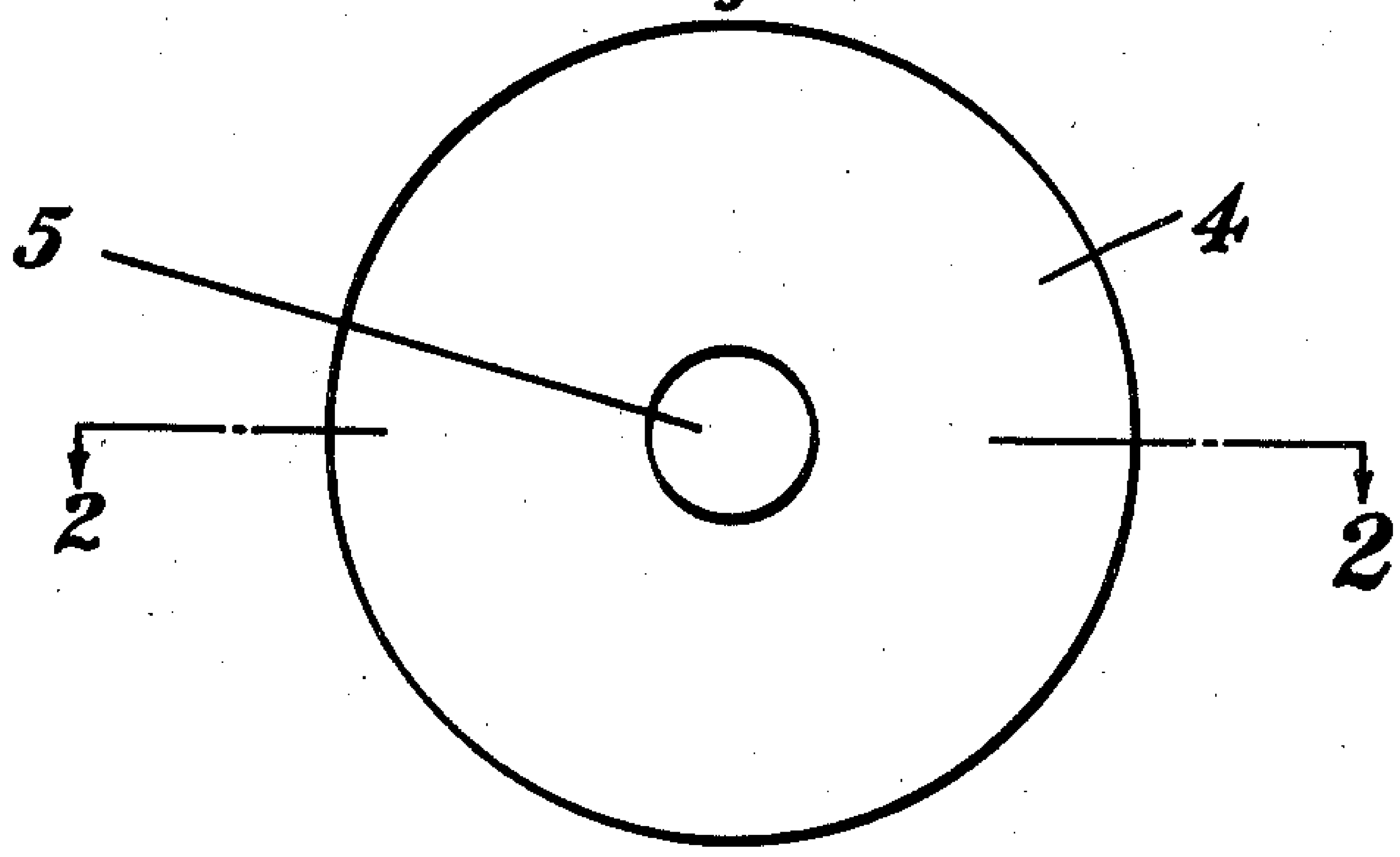


Fig. 2.

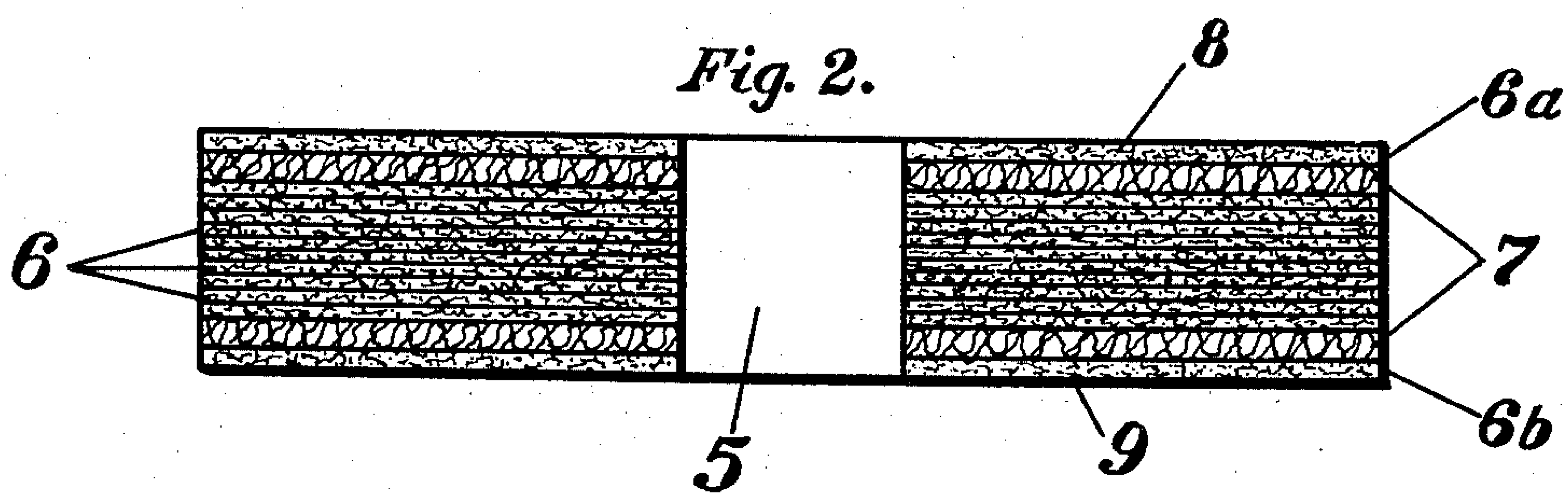
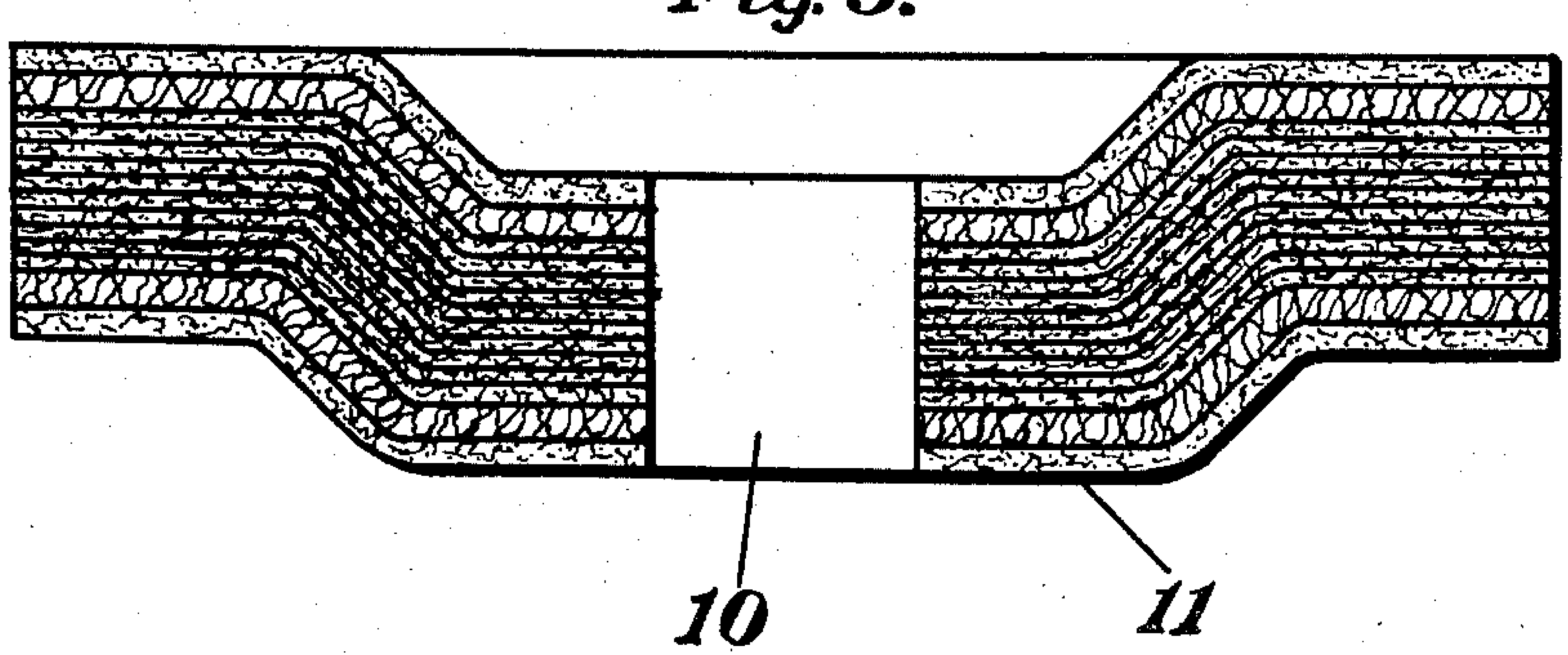


Fig. 3.



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ABRASIVE WHEEL

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10 Claims. (Cl. 51—206)

This invention relates to abrasive articles of manufacture. It is primarily concerned with abrasive wheels of the type which are used for cutting at or on the periphery of the wheel. Such wheels are often relatively thin with fairly expansive flat side surfaces. One wheel of this latter type is that commonly known to the trade as an abrasive cut-off or cutting-off wheel, and is used for cutting through rod, bar or sheet stock as well as for other grinding or cutting operations. Other wheels of similar structure are often used for dressing operations in the finishing of metal articles, grinding out fillets and the like, although due to their thinness they can also be used for cutting-off purposes.

The present invention is especially adapted to abrasive cutting-off wheels and wheels of similar structure and will therefore be primarily described as it pertains to such wheels although it is pointed out that it is also applicable to other types of grinding wheels wherein the grinding is performed at or on the periphery of the wheel.

Conventional cut-off wheels of the prior art are usually composed of abrasive grains held together by a suitable resinous or rubber bond. They are used at high speeds of revolution but in order to provide the requisite hardness to produce a fast and cool cutting rate without excessive wheel wear the bond is necessarily cured or vulcanized to an extremely hard condition. As a result the abrasive wheels so made are of very low flexural strength so that wheel breakage frequently occurs when the wheel is subjected to the least lateral stress or impact with not only loss of the wheel before it has served its useful life but with considerable danger to the operator. This deficiency in impact and/or flexural strengths has never been satisfactorily overcome.

It is an object of the present invention to provide an abrasive wheel having a satisfactory performance life and an acceptable high cutting rate.

It is a further object to provide an abrasive wheel which not only has a satisfactory life and cutting rate but also is of high impact and flexural strengths.

Other objects and advantages accruing from the practice of the present invention will become apparent as the description proceeds.

We have found that abrasive wheels with satisfactory life and cutting rate, having high impact and flexural strengths, can be made by forming the wheels of a felted fibrous abrasive-containing material and embedding within the

body of the wheel at the time that it is formed two or more sheets or plies of suitable non-abrasive fabric. Most satisfactory results have been obtained by using a resin-impregnated woven fabric which is preferably placed in from, but adjacent to, each flat side surface of the abrasive wheel. In other words, although the impact strength of an abrasive wheel, such as a thin cut-off wheel, composed of abrasive-included fibrous material is increased by placing the woven fabric plies within the wheel either adjacent the sides of the wheel or in more nearly the center portion laterally of the wheel, the flexural strength of such a wheel is not greatly improved unless the woven fabric layers are positioned in from, but in the vicinity of, the two wheel sides. The fabric to be selected for promoting the impact and flexural strengths by embodiment within the wheel should be of such character that the edges of the fabric at the periphery of the wheel will break down during the operation of the wheel without smearing or otherwise interfering with the grinding or cutting function. At the same time the fabric must have a durability and strength of its own sufficient to impart to the wheel the desired increase in both impact and flexural strengths. Such a combination of functions is most readily obtained by using a fabric which has been impregnated with a heat-hardenable resin. We have found a woven fabric such as a canvas, duck, or drill cloth impregnated with a phenolic condensation product resin to be highly satisfactory for the purpose.

A uniform thickness of the thin side layers of abrasive-included fibrous material forming the two flat side surfaces of the wheel, as well as a uniform thickness and density of the main body portion of abrasive-included fibrous material is best obtained by using an abrasive-included fibrous material in the form of thin sheets or plies cut to the shape of thin circular discs. The number of plies used for each side surface section, as well as for the central body portion, of the wheel will depend largely upon the thickness of wheel desired.

One abrasive-containing fibrous material which has been found highly suitable for making abrasive wheels in accordance with the present invention is the abrasive-included felted fibrous sheet material disclosed and fully described in U. S. Patents Nos. 2,284,738 and 2,284,739. In making an abrasive wheel such as an abrasive cutting-off wheel using the sheet material of the above patent the sheet material is died, punched or otherwise cut out in the form of a number of circular discs of a diameter slightly greater than the diameter of the wheel to be made. The sheet material either before or after it is cut to this form is sized with a suitable combining adhesive which is allowed to dry to a substantially non-tacky condition in which it is suitable for handling. One or more discs of the abrasive-containing felted fibrous sheet material are placed on the bottom mold plunger in a molding press, and superposed by a disc-shaped sheet of the chosen fabric. The abrasive-containing sheet material which is to make up most of the abrasive wheel body structure is then placed upon the fabric sheet, after which a second fabric sheet similar to the first sheet of fabric is superimposed on the pile of material, followed finally by one or more additional layers of the abrasive-containing felted fibrous sheet material. The entire assembly after alignment is then subjected to heat and pressure sufficient to compact and unite the various plies of material, the compacted wheel shape removed from the mold, and dressed if necessary, after which it is ready for use. If desired, the wheel can be formed by either a hot or cold pressing operation, followed by curing at a temperature and time sufficient to finally cure or mature the combining adhesive of the wheel structure.

In order to better understand the nature of the abrasive articles with which we are here concerned, reference is made to the accompanying drawing showing specific examples of abrasive wheels made in accordance with the present invention, and in which:

Figure 1 is a top plan view of an abrasive cut-off wheel made in accordance with the present invention;

Figure 2 is a highly enlarged sectional view through the line 2—2 of Figure 1; and

Figure 3 is a view, similar to that shown in Figure 2, of a modified form of abrasive wheel made in accordance with the present invention.

The exact manner in which abrasive wheels can be easily and economically made following the teachings of the present invention is most easily demonstrated by the following examples setting forth specific procedures for the making of illustrative abrasive products.

Example I

Abrasive cut-off wheels 16" in diameter and $\frac{3}{16}$" in thickness having a 1" arbor hole have been made as follows: An abrasive-containing felted fibrous sheet material of the type described in U. S. Patents Nos. 2,284,738 and 2,284,739 and composed of a felted cotton fiber base sheet held together by a casein adhesive and containing approximately 85–90% by weight of 24 grit size aluminum oxide abrasive grain is first sized on one side with a thin sizing coat of liquid phenolic resin prepared from the reaction product of 1 mole of phenol and from 1.1 to 2 moles of formaldehyde, said reaction being catalyzed by the addition of an alkaline catalyst, and the resin dried to a non-tacky condition. A number of circular discs 16¼" in diameter having centrally located arbor holes 1" in diameter are punched out of the sized abrasive-containing fibrous sheet material. One disc of the abrasive-included fibrous sheet material is placed on a 16⅝" diameter steel wheel mold plunger of the conventional type after which a disc-shaped sheet of resin-impregnated woven fabric of the same diameter is placed on the mold plunger on top of the single disc of abrasive-included fibrous sheet material. One material which has been satisfactorily used for this purpose is a blue cotton drill impregnated with a phenolic condensation product resin such as that obtained from the reaction of 1 mole of phenol with 1.5 moles of formaldehyde in the presence of a small amount of an organic primary amine catalyst. Ten layers of abrasive-included felted fibrous sheet material the same as that first placed on the mold plunger are then placed on top of the resin-impregnated fabric, followed by a single additional layer of resin-impregnated fabric which is topped in turn by a final single layer of the abrasive-included fibrous sheet material. The top mold plunger is then placed upon the assembled sheet material and the entire assembly axially aligned and pressed at 4000 pounds per square inch pressure at a temperature of 300° F. for 15 minutes. The thusly molded wheel is then removed from the press, dressed to size in accordance with conventional procedures, after which it is ready for use.

Referring further to Figures 1 and 2 of the drawing, which illustrate an abrasive cut-off wheel such as that made in accordance with Example I above, the abrasive wheel 4 having an arbor hole 5 is composed of abrasive-included felted fibrous sheet material 6 and two sheets 7 of resin-impregnated woven fabric, the woven fabric layers 7 being located within the wheel adjacent the flat side faces 8 and 9 of the wheel although they do not constitute the flat surfaces of the wheel since they are faced in each instance by surface layers 6*a* and 6*b* of the abrasive-included gelted fibrous sheet material. It is noted that the thickness of the wheel as depicted in Figure 2 of the drawing has been greatly exaggerated in order to bring out more clearly the structural make-up of the wheel.

A cut-off wheel of the described type has been demonstrated to have a highly satisfactory performance life and a high cutting rate. At the same time a cut-off wheel of the described type having two layers of resin-impregnated woven fabric adjacent the side faces of the wheel as shown in Figure 2 has been found to have a flexural strength as much as 35–40% greater than the strength of similar laminated abrasive cut-off wheels in which the resin-impregnated fabric layers have been omitted. As an example of the extremely high flexural strengths obtainable in wheels made in accordance with the present invention abrasive cut-off wheels of the type hereinabove described have been subjected to a grinding test in which the wheels have been used to cut directly into a piece of solid brass rod 2" in diameter to a depth of more than 1" whereupon the brass rod without removal of the wheel is turned laterally through an angle as high as 45° in each direction. Abrasive wheels of the present invention when subjected to such punishment, cut wedge-shaped sections out of the brass rod without breakage of the abrasive wheel. Conventional resin bonded or rubber bonded cut-off wheels of the same diameter and thickness, and also abrasive cut-off wheels of similar size composed of abrasive-included fibrous sheet material in which the plies of resin-impregnated fabric have been omitted, when subjected to the same test failed to stand up, usually shattering with explosive violence. The ability of the wheels of the present invention to resist breakage or damage under the severe conditions of such a test under which other wheels generally fail is a dramatic demonstration of their marked superiority over the conventional wheel types.

The vast superiority in strength together with the highly satisfactory cutting rate and performance life which distinguishes the present wheels renders them highly suitable for many severe grinding and cutting operations heretofore considered impractical or impossible to perform. Furthermore, the added safety of use of the present wheels in itself is of great benefit.

Example II

Thin abrasive wheels, such as that illustrated in Figure 3 of the drawing, 12″ in diameter and ⅛″ thick, with a 1″ arbor hole 10 and having a depressed center portion 11, have been made following the same general operational procedure set forth in Example I above except that the mold is provided with top and bottom plungers having such contour as to mold the discs with the centers having a depressed contour. As in Figure 2, the thickness of the wheel shown in Fig. 3 of the drawing has been highly exaggerated in order to make clear the actual structural character of the wheel. Such wheels possess the same improved impact and flexural strengths secured in the case of the cut-off wheels described in Example I above. They are particularly adapted because of their specific design, for use in grinding out and dressing fillets and reentrant portions of metallic or non-metallic shapes wherein the grinding is done at, but not entirely on, the periphery of the wheel or disc and the abrasive wheel is continually subjected to lateral stresses so that as a result a high flexural strength is of prime importance.

In addition to the improvement in flexural and impact strengths obtained in the final product, the present invention offers certain manufacturing benefits and advantages of importance. For example, heretofore, in the fabrication of thin cut-off wheels, especially in larger size wheels such as cutting-off wheels 16″ in diameter and ⁵⁄₃₂″ in thickness, large numbers of the wheels made have had to be rejected due to warpage. Obviously, an article such as a cutting-off wheel operated at high speeds in grinding and cutting operations must run true in order to cut safely and efficiently without breakage. The incidence of warpage in wheels during their fabrication has been greatly reduced in the case of the present wheels. Therefore, the reduction or elimination of such manufacturing difficulties as a result of the present invention still further enhances its value to the industry.

In practicing the invention it is obvious that any of the abrasive materials in common use may be employed as the abrasive contained in the fibrous body of the wheel structure, such as silicon carbide, diamonds, boron carbide, fused aluminum oxide, flint, corundum, emery, rouge, and similar substances. The size of the abrasive particles may vary from the finest polishing or buffing powders to the coarser grit sizes used in grinding.

Although a resin-impregnated blue drill cloth has been specified in the examples above as the non-abrasive fabric to be included within the wheel structure it is not intended to limit the invention to the specific material named. Very satisfactory results, as reflected by the improved impact and flexural strengths secured and the highly satisfactory cutting performance and life maintained through their use, have been obtained by the use of various resin-impregnated woven fabrics typified by various stout, twilled linen or cotton fabrics known as drill or drill cloth, untwilled linen or cotton fabrics such as duck, or strong woven fabrics such as canvas. Such fabrics are either impregnated with a suitable resin prior to insertion in the mold or a sufficient amount of resin is otherwise provided to bring about such impregnation during the molding operation such as, by example, having the layers of abrasive-included sheet material adjacent the fibrous reinforcing layers provided with a sufficient amount of resin size to impregnate the fabric during the molding operation. For example, a duck cloth, such as that known and sold by Spaulding Fibre Company as 9 oz. "Spauldite" uncured resin-filled fabric containing 50-60% resin solids of a cresylic acid-modified phenol formaldehyde heat-hardenable resins has been found suitable in the making of abrasive cut-off wheels of large diameter wherein the abrasive in the fibrous sheet material is granular silicon carbide. Also, blue drills impregnated with approximately 50% by weight of a liquid phenolic resin has been found very suitable in the making of abrasive cut-off wheels wherein fused aluminum oxide is the abrasive material in the fibrous sheets. However, this is not intended to mean that we desire to restrict ourselves to the use of any specific fabric or resin in combination with any specific abrasive material. Other fabrics either felted or woven may be used without departing from the spirit of the invention. Various resins may be used as the impregnating adhesive for the fabric layers such as urea formaldehyde resins, melamine formaldehyde resins, phenol-furfural resins, unmodified alkyd resins of the glycerol-phthalic acid type and amine-aldehyde resin-modified alkyd resins.

Although the examples given herein have specified a phenolic condensation product resin as the combining adhesive used for sizing the laminations of abrasive-included fibrous material, other adhesives may be used, such as melamine formaldehyde resins, urea formaldehyde resins, unsaturated polyesters such as polymerized glycol maleate or polymerized diallyl ester crosslinked with unsaturated monomers such as methyl methacrylate, styrene or diallyl phthalate, and polyfunctional polyesters such as polymerized diallyl maleate or fumarate. The amount and kind of combining adhesive used will depend largely upon the hardness grade and properties desired in the finished product. For most grades of wheels a phenolic resin in solution form has been found to give excellent results.

While the specific examples hereinabove set forth have employed only 1 layer or sheet of abrasive-included fibrous material between the resin-impregnated fabric and each side face of the wheel it is permissible to use more than 1 sheet of the abrasive-included fibrous material on each side of the wheel.

We have sometimes found it desirable to impart an added configuration of roughness to the side faces of the wheels by placing a sheet of burlap or similar material between the mold plungers and the assembly of sheet material whereby the impression or pattern of the burlap is impressed on the wheel sides during the pressing operation. The resulting increased roughness of the wheel sides tends to promote a greater freedom of cut, especially in deep-cutting operations.

Having described the invention it is desired to claim:

1. An abrasive wheel comprising a plurality of thin felted, abrasive-containing layers of fibrous

material compressed and adhesively united, said wheel having embedded therein at least two layers of resin-impregnated woven fabric substantially coextensive in area with the flat side area of said wheel.

2. An abrasive cut-off wheel composed of a body of abrasive-containing felted fibrous material and having a layer of woven fabric substantially coextensive in area with the flat side of the wheel embedded within but adjacent to each flat side surface thereof.

3. An abrasive cut-off wheel composed of a body of abrasive-containing felted fibrous material and having a layer of resin-impregnated woven fabric substantially coextensive in area with the flat side of the wheel embedded within but adjacent to each flat side surface thereof.

4. An abrasive cut-off wheel conforming to claim 3 in which the impregnating resin is a resinous phenolic condensation product.

5. An abrasive wheel comprising in the following order from one flat side to the opposing flat side: a thin layer of abrasive-containing felted fibrous material, a layer of resin-impregnated woven fibrous material, a plurality of layers of abrasive-containing felted fibrous material, a layer of resin-impregnated woven fibrous material, and a layer of abrasive-containing felted fibrous material, all said layers being compressed together and adhesively united.

6. An abrasive cut-off wheel composed of a body of abrasive-containing felted fibrous material and having at least one layer of resin-impregnated non-abrasive fabric substantially coextensive in area with the flat side of the wheel embedded within but adjacent to each flat side surface thereof.

7. An abrasive cut-off wheel comprising a plurality of abrasive-containing felted fibrous sheets composed essentially of abrasive grains, felted fibers and binder, said sheets of abrasive material being compressed and adhesively united, said wheel containing within the body thereof adjacent each flat side at least one layer of resin-impregnated non-abrasive fibrous material substantially coextensive in area with the side area of said wheel.

8. An abrasive wheel comprising in the following order from one flat side to the opposing flat side: at least 1 sheet of abrasive-containing felted fibrous material, at least 1 sheet of resin-impregnated woven fibrous material, a plurality of layers of abrasive-containing felted fibrous material, at least 1 sheet of resin-impregnated woven fibrous material, and at least 1 sheet of abrasive-containing felted fibrous material, all said layers being compressed together and adhesively united.

9. An abrasive cut-off wheel composed of a body of abrasive-containing felted fibrous material and having a layer of resin-impregnated non-abrasive fabric substantially coextensive in area with the flat side of the wheel embedded within but adjacent to each flat side surface thereof.

10. An abrasive wheel comprising a plurality of thin felted, abrasive-containing layers of fibrous material compressed and adhesively united, said wheel having embedded therein at least one sheet of resin-impregnated woven fabric adjacent each flat side of the wheel.

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No references cited.