

Oct. 8, 1957

H. D. MacMASTER

2,808,688

LAMINATED GRINDING WHEEL

Filed Sept. 24, 1953

2 Sheets-Sheet 1

FIG. 1-

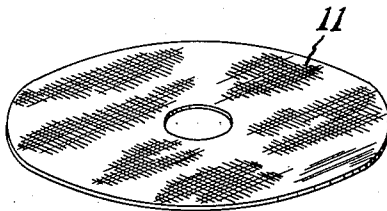


FIG. 2 -

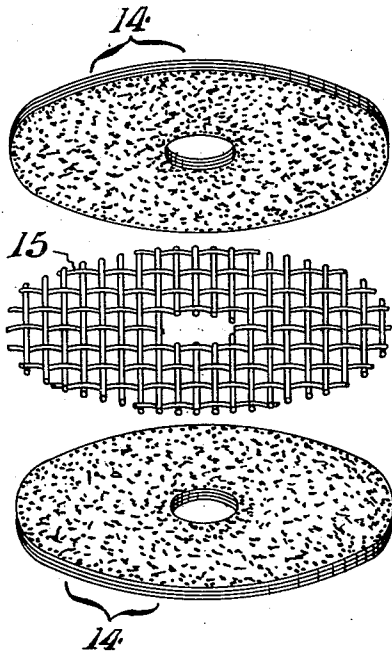
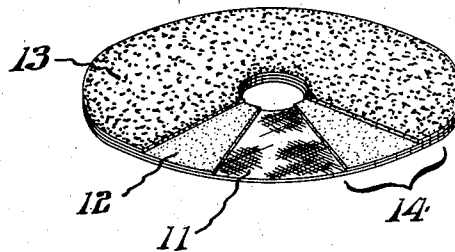


FIG. 4 -

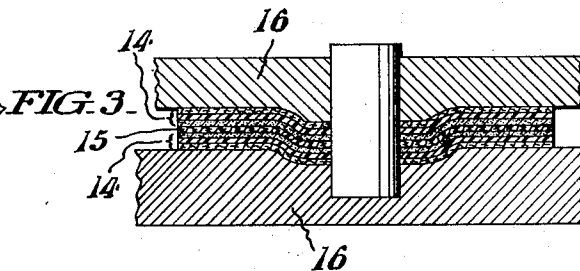


FIG. 6 -

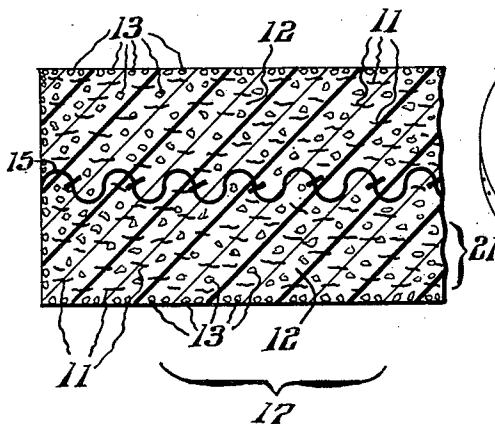
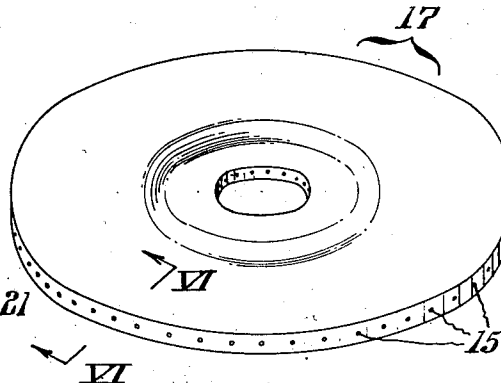


FIG. 5 -



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FIG. 7.

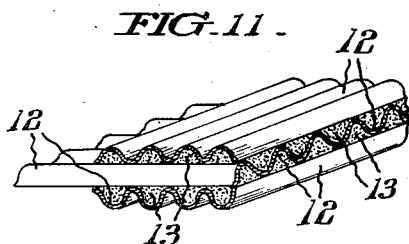
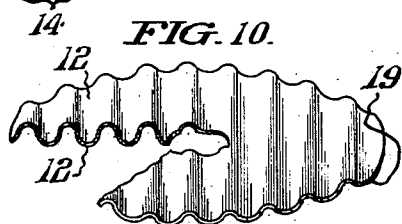
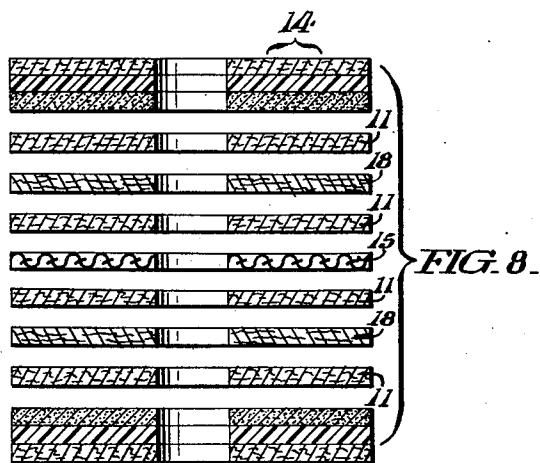
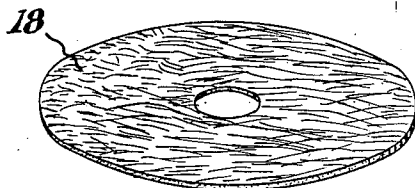


FIG. 9.

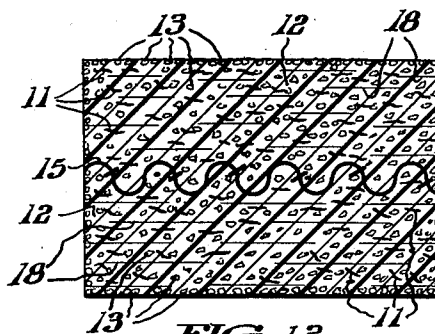


FIG. 12.

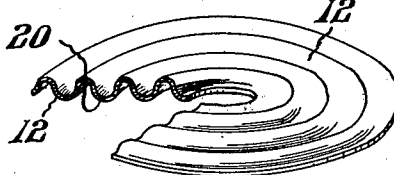
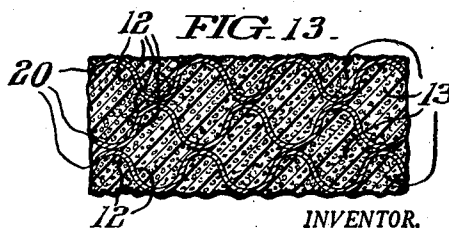


FIG. 13.



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LAMINATED GRINDING WHEEL

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Application September 24, 1953, Serial No. 382,061

10 Claims. (Cl. 51—193)

This invention relates to a laminated grinding wheel and the method of making it and more specifically to a grinding wheel having a resinous matrix combining a number of laminations contributing individual qualities of strength, resilience and hardness to the completed wheel. It is an object of the invention to provide an economical grinding wheel having high tensile and bending strengths and further to provide a method of making such a grinding wheel in which the characteristics of the wheel may be varied by altering its laminar construction and composition.

It is another object of the invention to provide a laminated grinding wheel in which the abrasive particles are distributed directly in the resin matrix. Previous patents, and in particular the patent to Goepfert et al., No. 2,540,112, have shown laminated grinding wheels made from special abrasive-included felt discs. It is apparent that the abrasive to fiber ratio is thus limited to the particular felt fabric and that the abrasives are not imbedded directly in the resin. By my invention, the abrasive grains may be included in the wheel free of the fibrous laminations and are fixed in the resin bonding material, giving all the advantages of a normal bonded abrasive grinding wheel.

It is a further object of the invention to provide a grinding wheel having high tensile and bending strengths, and the method of making such a grinding wheel whereby the strength characteristics may be varied in a simple and predictable manner.

It is a further object of the invention to provide a grinding wheel having a substantially uniform compositional cross section along any diameter, so that constant grinding rates may be maintained.

It is a still further object of the invention to provide an economical method of making laminated grinding wheels of high flexural rigidity whereby the several laminations may be pre-finished prior to ultimate formation of the grinding wheel.

It is another object of the invention to provide a laminated grinding wheel having high flexural and tensile strength wherein the abrasive grains are disposed in a normal resinous grinding mix so that the grinding characteristics of the wheel may be easily and economically determined.

Several specific embodiments of my invention are shown in the accompanying drawings of which:

Fig. 1 is a perspective view of a disc of felted cotton fibers;

Fig. 2 is a perspective view partially cut away, of a felt disc such as in Fig. 1, having a coating of an adhesive synthetic resin and a layer of abrasive grains thereon;

Fig. 3 is an exaggerated perspective view showing the respective positions of coated discs as shown in Fig. 2 with respect to a loosely woven reinforcing disc in a simple grinding wheel made according to my invention;

Fig. 4 is a sectional view of the laminations of a grinding wheel made according to my invention, shown

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between the walls of a press used to compress the laminations into a grinding wheel;

Fig. 5 is a perspective view of a finished grinding wheel made according to my invention;

Fig. 6 is an enlarged diagrammatic sectional view showing the cross section of a grinding wheel made according to my invention;

Fig. 7 is a perspective view of a disc of felted glass fibers;

Fig. 8 is a sectional view of the laminations of a grinding wheel made according to my invention;

Fig. 9 is an enlarged diagrammatic sectional view of one embodiment of my invention made from the laminations shown in Fig. 8;

Fig. 10 is a perspective view of a resin-coated paper disc corrugated along parallel chords used in one embodiment of my invention;

Fig. 11 is a perspective view of combined laminations of the corrugated paper shown in Fig. 10, including a resin adhesive and abrasive grains;

Fig. 12 is a perspective view of a concentrically corrugated resin-coated paper disc used in one embodiment of my invention;

Fig. 13 is a sectional view of combined laminations of the corrugated paper shown in Fig. 12, including a resin adhesive and abrasive grains.

According to the invention a grinding wheel is produced by combining under heat and pressure a plurality of laminations of various materials prepared in disc form having an arbor hole cut in the center and having an outside diameter corresponding to the diameter of the wheel to be made. The laminations include a resinous bonding material, an abrasive grain mix and felted and woven reinforcing discs. I have found that laminations including these materials can be prepared and combined in certain ways to produce grinding wheels of long life, high metal removal rates and excellent flexural and tensile strengths.

Fig. 1 shows a simple felt disc 11 cut from a mat of a fibrous material, such as cotton. The weight of the cotton has been found to be satisfactory between two ounces per square yard and ten ounces per square yard, but a weight of about three ounces is preferable. An increase in weight of the cotton discs tends to increase the flexural and tensile strengths of the grinding wheel and to lower its cutting hardness.

The felt disc 11 is first coated on one side with a layer of a synthetic resin 12 as shown in Fig. 2, which is applied at a rate of about 60 grams per square foot. Thermosetting phenol-formaldehyde has been found to be suitable for this purpose. As applied, the resin contains about 50 percent solids, the remainder being water with some alcohol.

The felt disc 11, coated with resin 12, is then covered with a layer of abrasive grain mix 13. The grain mix 13 may be any desired commercially useful mix having a resin binder used in ordinary molded grinding wheels. The amount of resin 13, which is also preferably thermosetting phenol-formaldehyde, may be varied according to the characteristics desired in the finished grinding wheel. Increasing the amount of resin results in increasing the hardness of the wheel and reduces the ability of the grains to be dislodged during grinding operation. The abrasive grains 13 may be of any desired type, such as aluminum oxide or silicon carbide, and of any desired size. The grains 13 are spread on the adhesive 12 in a layer of one grain thickness. In this way each grain of abrasive is supported on both sides by a fabric reinforcement as shown in Fig. 3 and Fig. 8. The resin content of the wheel may be increased by coating the other side of the disc with resin. This serves to provide a greater impregnation of the felt disc with resin than is accom-

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plished by merely increasing the resin content of the abrasive mix.

The coated felt disc 14, Fig. 2, is subjected to a drying-out operation to remove the volatile matter from the resins and to limit their flow upon subsequent heating in the press. Heating time of three minutes to final temperature of 260° F. has been successfully used. The final temperature in this time may be varied from 240° F. to 280° F., but at the lower temperature gases tend to form, causing delamination of the layers, while at the higher temperature the effect of the drying-out on the flow properties of the resins may become such that they are unsuitable for further bonding when the layers are combined in the grinding wheel.

A plurality of abrasive-coated felt discs 14 are combined as shown in Figs. 3 and 8. The combination of Fig. 3 includes two abrasive-coated discs 14 face to face, with a loosely woven reinforcing mat 15 made up of strands of a high tensile strength material such as nylon or a ductile metal inserted between them. By "loosely woven" is meant having a mesh size between 6 and 20 depending upon the size of the abrasive grains used. The openings should be sufficiently large to permit the grains to pass through. Several types of material have been found useful in the reinforcing disc 15. The strands may be composed of tightly twisted plain brown paper. For higher strength glass or nylon filaments may be included in the core of the twisted paper. A woven cotton fabric, such as Leno tire cord may also be used. As shown in Fig. 7, a disc of felted glass fibers 18 may be used in place of the loosely woven reinforcing disc 15. However, when a glass fiber material is placed directly between two layers of abrasive grain, the sharp, hard adhesive masticates the glass when the wheel is formed under pressure, and therefore it is preferably used in the embodiment of Fig. 8, hereinafter described.

The physical characteristics of the grinding wheel may be varied in a predictable manner by changing the number and position of the elements shown in Fig. 3. The number of layers used of course will effect the ultimate thickness of the grinding wheel.

The finished grinding wheel 17 is produced by combining the various layers described above under heat and pressure in a press 16, as shown in Fig. 4. A grinding wheel may be produced having four layers of abrasive-coated felt fabric and one loosely woven reinforcing mat by compressing combined layers at 1500 pounds per square inch and 300° F. for 15 minutes. More layers take as much as 45 minutes. A broad range of pressures may be employed from 500 pounds per square inch to 1500 pounds per square inch, and neither of these figures is necessarily limiting. The temperature, however, must be sufficiently high to completely cure the resin, since if it is not set, it will smear during grinding and reduce the cutting effectiveness of the abrasive grains. The upper limit upon temperature is set by the combustibility of the cotton which tends to char and lose its strength when held at extremely high temperatures for any length of time.

Fig. 6 shows an enlarged partial cross section of a grinding wheel produced from the laminations shown in Fig. 3. Under pressure the felt fabric 11 is greatly reduced in thickness, tending to produce a comparatively substantially homogeneous distribution of abrasive particles 13 throughout the cross section, interspersing them with the fibers of the felt fabric 11. As the resin 12 flows at the increased temperature of molding, it flows through the fabric layers 11 producing a complete matrix of resin 21, including all of the other laminated elements. It will be apparent that the high temperature viscosity of the resins is of paramount importance in establishing the construction of the wheel at this stage. This will have been, to a great extent, already determined in the drying-out operation of the abrasive-coated disc heretofore described. It is thus desirable that in

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drying out the abrasive-covered disc 14, excessively high temperatures be avoided, in order that the high temperature flow properties of the resins will be preserved.

A grinding wheel of extremely high tensile and flexural strength may be produced by using a fiber glass disc 18, shown in Fig. 7, in combination with the other elements already disclosed. In such a wheel it is important that the fiber glass be somewhat protected from the abrasive particles. This may be achieved by inserting the fiber glass 18, where used, between independent discs of a soft-felted fabric 11, as shown in Fig. 8. The glass mat 18 preferably ranges in thickness between .005 inch and .040 inch, and may also be coated with a synthetic resin, such as thermo-setting phenol-formaldehyde compatible with the resins used in the other laminations of the wheel. The resultant grinding wheel as shown in cross section, Fig. 9, is bonded in the manner as shown in Fig. 4. In this case strata of glass fibers 18 appear throughout the wheel, largely protected from the abrasive grains by the fibers of the soft felt fabric 11.

I have found that inexpensive substitutes may be employed in place of the felted cotton fabric 11 shown in Fig. 1. Ordinary brown kraft paper made from unsized wood pulp, when corrugated, displays satisfactory strength properties. As shown in Fig. 10, the paper disc 19 may be corrugated in a parallel manner, or, as shown in Fig. 12, the corrugations may be concentrically impressed about the center opening of the disc 20. As in the case of the felted fabric 11, the corrugated paper 19 or 20 is coated in the depressions on both sides with a thermo-setting synthetic resin 12. The corrugations are then filled with a suitable abrasive mix 13 and several layers are combined together, as shown in Figs. 11 and 13. It will be obvious that, due to the corrugations of the paper 19 or 20, a relatively larger quantity of abrasive mix 13 will be employed when the corrugated paper is used than when the cotton felt is used, thus producing a wheel of higher grinding hardness but of relatively lower tensile and flexural strength.

It is of paramount importance to my invention that felted fabrics be used as laminations to hold the abrasive grain. This importance is derived from the fact that the felted fabric has essentially equal strength in all directions. Furthermore, as I have pointed out, the abrasive grains are not included within the felted fabric itself, which tends to reduce its tensile strength, and further to reduce the grinding hardness of the grinding wheel itself. Felted material is of course superior to woven material for this purpose because it is possible for the fibers to move individually in the resin matrix during the pressing operation.

Throughout, I have suggested that phenol-formaldehyde resin be used as the bonding and adhesive material. This may be used either in the liquid or powdered form. It will be obvious, however, that any thermo-setting resin such as urea formaldehyde, melamine formaldehyde, epoxy and alkyd and polyester resins may be used in my invention depending upon the particular characteristics desired.

It will further be apparent that particular types of bonding compositions, such as those having a rubber base, will also be satisfactory in my invention.

One of the primary advantages resulting from my invention is the flexibility in manufacture which is provided. The various elements of the grinding wheel may be prepared and stockpiled without limiting the types of grinding wheels that may be produced from them. Thus abrasive-coated discs may be prepared and combined, as has been shown, in different numbers with different reinforcing materials having varied amounts of resin. A wide range of grinding wheel characteristics may thus be achieved with a minimum of individual preparation in each case.

Having thus described my invention, I claim:

1. A laminated grinding wheel comprising in consecu-

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tive layers a cotton felt disc, a layer of synthetic resin, a layer of abrasive grains coated with synthetic resin, a loosely woven reinforcing disc disposed medially of said wheel, abrasive grains coated with a layer of synthetic resin, a synthetic resin, and a second cotton felt disc.

2. A laminated grinding wheel comprising a matrix of a synthetic resin, abrasive grains disposed throughout said matrix, cotton felt fibers randomly disposed substantially laminarly in said matrix, and an open mesh fabric of non-metallic reinforcing material disposed in one plane in said matrix.

3. In a laminated grinding wheel, a matrix of synthetic resin material including abrasive grains and a reinforcing disc comprising a loosely woven mat of tightly twisted paper strands.

4. A laminated grinding wheel comprising in consecutive layers a cotton felt disc, a synthetic resin, abrasive grains coated with synthetic resin, a cotton felt disc, a disc of felted glass fibers, a cotton felt disc, a loosely woven reinforcing disc, a cotton felt disc, a disc of felted glass fibers, a cotton felt disc, abrasive grains coated with synthetic resin, a synthetic resin, and a cotton felt disc.

5. A substantially rigid abrasive article comprising a plurality of layers of felted fibrous material coated with a phenol-formaldehyde resin and abrasive grains coated with a phenolformaldehyde resin, a plurality of layers of felted glass fibers having a layer of cotton felt disposed on either side thereof and a layer of a loosely woven non-metallic material.

6. A laminated grinding wheel comprising a matrix of a synthetic resin, abrasive grains disposed throughout said matrix, layers of a felted cotton fabric disposed throughout said matrix, and a loosely woven reinforcing layer of a high tensile strength material sheathed in a paper coating.

7. A method of making a laminated grinding wheel comprising the steps of coating a plurality of discs of cotton felt fabric on one side with a liquid, synthetic heat-hardenable resin, spreading the moistened surfaces with layers of abrasive grains coated with a synthetic heat-hardenable resin, combining a plurality of said discs on either side of a loosely woven mat of a non-metallic reinforcing material so that the grain sides face the said

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loosely woven mat and combining the whole under heat and pressure sufficient to cause the resins to flow through said discs and said mat and to harden upon cooling.

8. A method of making a laminated grinding wheel comprising the steps of coating a plurality of discs of cotton felt fabric on both sides with a liquid, synthetic heat-hardenable resin, spreading one of said moistened surfaces with a layer of abrasive grains coated with a synthetic heat-hardenable resin, combining a plurality of said discs on either side of a loosely woven mat of a non-metallic reinforcing material so that the grain sides face the said loosely woven mat and combining the whole under heat and pressure sufficient to cause the resins to flow through said cotton discs and said mat and to harden upon cooling.

9. A laminated grinding wheel comprising a matrix including a synthetic resin, abrasive grains disposed throughout said matrix, fibers of a felted fibrous material randomly disposed substantially laminarly in said matrix, and an open mesh fabric of non-metallic reinforcing material disposed in one plane in said matrix.

10. A laminated grinding wheel comprising a plurality of discs of uncarded felted fibrous material, synthetic resin, abrasive grains coated with synthetic resin, and an open mesh reinforcing disc.

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