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R. C. BENNER ET AL

2,028,183

ABRASIVE WHEEL AND METHOD OF MAKING THE SAME

Filed April 18, 1930 2 Sheets-Sheet 1

Fig. 1

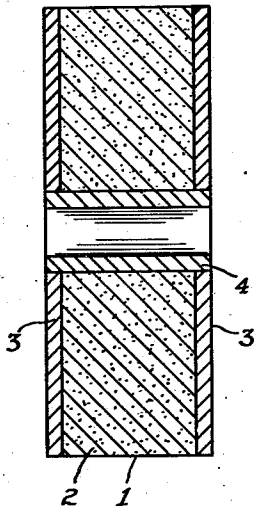


Fig. 4

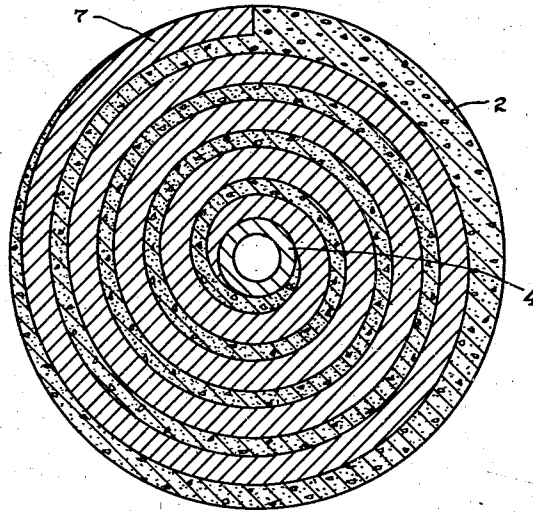


Fig. 2.

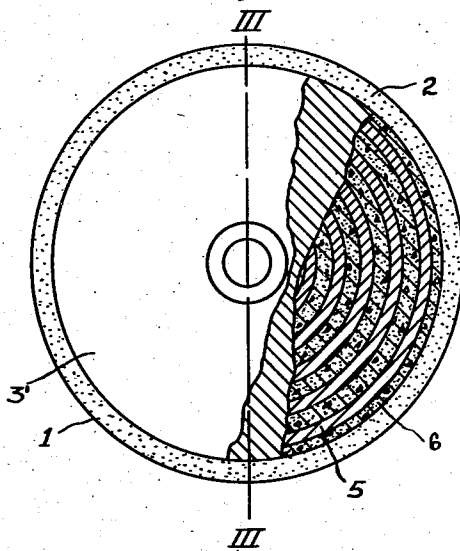
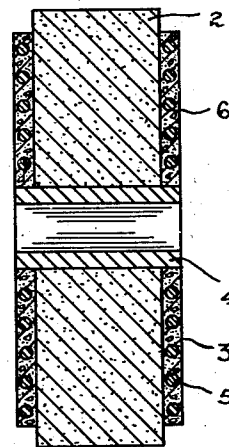


Fig. 3.



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2 Sheets-Sheet 2

Fig. 5.

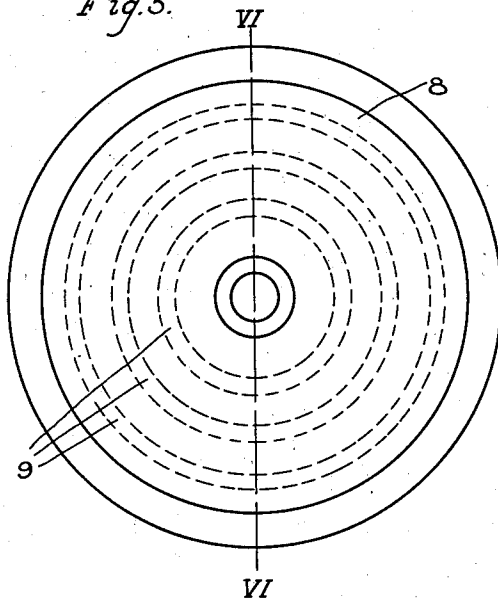


Fig. 6.

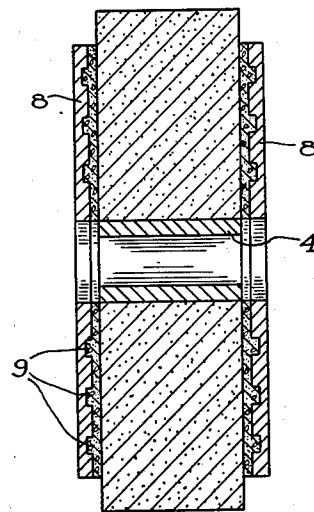
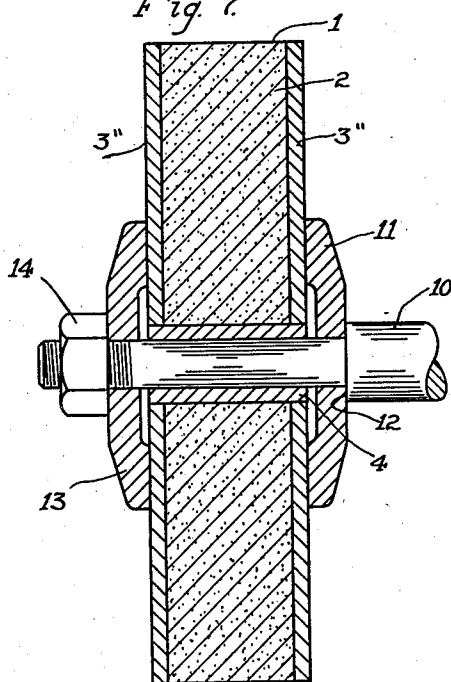


Fig. 7.



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## UNITED STATES PATENT OFFICE

2,028,183

ABRASIVE WHEEL AND METHOD OF  
MAKING THE SAME

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16 Claims. (Cl. 51-168)

This invention relates to an improvement in abrasive wheels and the method of making the same. It pertains to the strengthening of abrasive wheels of bonded granular abrasive material by the addition of a member or members that reinforce the wheel against the stresses incident to operation at high peripheral speeds.

It is common practice in industry to operate grinding wheels at peripheral speeds of 5500 feet per minute and greater. Centrifugal forces set up stresses in grinding wheels rotating at such speeds that frequently result in wheel breakage, particularly if the wheel is subjected to other stresses resulting from such causes as elevated temperature, impact from the application of the work, or torsion from heavy loading. Centrifugal stresses must be seriously considered in the operation of grinding wheels since they increase in magnitude as the square of the velocity.

Various means have been employed to reduce breakage or to provide greater safety in cases of breakage. The wheels have been made thicker at the arbor hole or center and tapered toward the periphery in order to permit driving flanges of comparable concavity to hold the pieces in case of breakage. Thin metal plates with a coating of soft rubber have been interposed between the wheel and each driving flange in order to provide a cushion that will restrain pieces from flying out when the wheel breaks. These latter rubber coated metal plates have been attached to the sides of the wheel by means of a soft rubber cement and also have been applied to the wheel by the clamping action of the flanges.

Each of these methods is effective to a certain degree in holding the pieces after breakage occurs, but none of them are materially effective in preventing breakage. We have found that the bursting speed of abrasive wheels can be greatly increased by attaching to one or both faces of the wheel a reinforcing member that reduces the tendency of the wheel to expand in diameter when it is rotating.

In the drawings:

Figure 1 shows a cross-section through a diameter of a wheel reinforced by two lateral members.

Figure 2 is a view in elevation partly broken away to show the metal elements of a lateral reinforcement.

Figure 3 shows a cross-sectional view along the line III-III of Figure 2.

Figure 4 is a view in elevation that shows one type of metal member in position on the wheel to receive the embedding material.

Figure 5 is a view showing a wheel with a scored metal plate attached to its face.

Figure 6 is a cross-sectional view along the line VI-VI of Figure 5; and

Figure 7 is a cross-sectional view of a reinforced wheel mounted and ready for operation.

The wheel 1 illustrated in Figure 1 comprises an abrasive member 2 with two intimately attached reinforcing members (3) (3). The reinforcing members illustrated in this figure are simple ones without embedded elements.

In Figures 2 and 3 the wheel 1 comprises an abrasive member 2 reinforced by two reinforcing members (3') (3') which comprise metal members 5 embedded in an adhesive medium 6. The members 5 are shown as rings of circular cross-section but other cross-sectional shapes or other forms than rings may be used.

Figure 4 shows a metal member 7 in the form of a spiral, while in Figures 5 and 6 is shown a metal disk 8 having concentric grooves 9 in one of its faces.

The assembly shown partly in section in Figure 7 illustrates the method of mounting the wheel for use. In this figure the wheel 1 comprising the abrasive member 2 with reinforcing members 3' and 3' is centered on the shaft 10 by means of a bushing 4 of soft metal, such as lead or babbitt, or of wood. The wheel 1 is held against the flange 11, which bears on the shoulder 12, by means of a flange 13, which is drawn up by the nut 14.

One way of providing greater strength in the wheel involves the use of members that are intimately united to the abrasive and are more rigid than the bonded abrasive member. By this means some of the stresses set up in the abrasive wheel by centrifugal force are, at least in effect, transferred to, and borne by, the reinforcing member or members with the result that the tendency of the abrasive wheel to expand in diameter is lessened. If the member that is intimately united to the abrasive wheel not only is rigid enough to bear part of the stress that tends to make the wheel expand but also normally exerts a contractile force inwardly of the wheel, this force or stress will oppose the stresses caused by the centrifugal forces incident to rotation. This contractile force may be obtained in the reinforcement during the application of the reinforcement to the wheel under the action of heat by utilizing as reinforcements materials which may be effectively united with the bonded abrasive and which will shrink more than the

bonded abrasive does upon cooling. Naturally, the degree of difference between the shrinkage of the bonded abrasive and of the reinforcing member must be controlled to prevent breakage of the wheel. Our previously filed applications bearing Serial Numbers 313,087 and 336,557, of which the present application is a continuation in part, disclose this subject matter.

It may be stated that, in general, the greater the degree of difference between the shrinkage of the reinforcement and that of the bonded abrasive the greater will be the strengthening effect of the reinforcement upon the wheel; however, the difference may be great enough to cause the reinforcement to fracture the wheel upon cooling. We provide against such a contingency by choosing a reinforcing member that will produce the maximum stress consistent with freedom from fracturing the wheel. Because of the large number of bonded abrasive compositions, each composition having particular physical characteristics, it is not practicable to make a specific statement defining the material that will provide maximum reinforcement without undue stress for each bonded abrasive. The reinforcing material preferably is chosen for one particular abrasive composition.

The choice of the material or materials for the reinforcement of any particular bonded abrasive composition involves a number of factors, among which are the coefficients of thermal expansion of the bonded abrasive, and of the material or materials employed in the reinforcing members. In addition to these the modulus of elasticity and the thickness of the bonded abrasive and of the reinforcing material or materials, and the temperature at which the reinforcements are applied to the wheels are involved in the choice of a reinforcing body that will provide the maximum reinforcement without undue stresses. The effectiveness of the reinforcement depends also upon the aging characteristics of the bonded abrasive and the reinforcing body. Alleviation of the strain caused by the shrinkage of the reinforcement decreases the strengthening effect of the reinforcement, and weakening of the bonded abrasive under continued strain reduces the allowable strain consistent with safety from undue stresses.

Because of the number of factors involved and because of the interdependence of the physical form and properties of one material upon those of the other material or materials, the absolute determination of the suitability of a particular combination of materials by calculation is difficult and in some cases at least a practical impossibility. We first determine the probable suitability from the physical characteristics of the material and then we provide maximum reinforcement consistent with freedom from undue stresses by experimentation.

In the preliminary choice of the reinforcement we are guided by two of the characteristics of the material in addition to its strength. These are its coefficient of expansion and its modulus of elasticity. A material that has a low modulus of elasticity, with respect to that of the bonded abrasive, may have a relatively high coefficient of expansion. But a material that has a relatively high modulus of elasticity should have, in general, only a moderately higher coefficient of expansion than that of the bonded abrasive.

We have found that the characteristics of hard rubber can be modified to adapt it to bonded

abrasive articles of different coefficients of thermal expansion. A typical example is

|                   | Parts |
|-------------------|-------|
| Rubber-----       | 10    |
| Sulphur-----      | 2.5   |
| SiC—500 mesh----- | 90    |

which, when cured to the full extent possible with that proportion of sulphur, has been found satisfactory as a reinforcing material for a medium grade wheel of a specific type of bond and abrasive but not necessarily for others.

It has, approximately, a coefficient of thermal expansion of  $20 \times 10^{-6}/^{\circ}\text{C}^{\circ}$ , a modulus of elasticity of  $1.5 \times 10^6 \text{ #/in}^2$  and a tensile strength of 2,000 pounds per square inch.

The following specific methods of applying reinforcements are given by way of illustration and are not intended to limit the invention to the specific materials or manipulative details disclosed, nor are they intended to limit the process to the specific steps or sequence of steps.

The abrasive surfaces that are to receive the reinforcing members are first primed with the rubber compound softened with a volatile softer such as benzol. The ratio of benzol to rubber compound may be varied as required, but it has been found that 2 parts of benzol and 1 part of the above rubber compound form a priming material that may be applied easily by brushing and leaves a satisfactory coating of rubber compound on the abrasive surface after the solvent has evaporated. If a thicker coating of rubber compound than that produced by one application, either by brushing or by spraying, is desired, additional coats of the solvent-softener compound may be applied. Sufficient time should elapse between coatings to permit the solvent to evaporate completely before a subsequent coat is applied.

A sheet of the rubber compound, approximately  $\frac{1}{8}$  inch thick, is then applied to each of the primed surfaces of the abrasive wheels and is cured by heat and pressure. The wheel with a sheet of the rubber compound on each of its side faces is then subjected to a uniform pressure of approximately 30 lbs. per square inch, and while this pressure is maintained is heated to approximately  $320^{\circ}\text{F}.$

When the curing is completed the wheel is cooled slowly, for example, at a uniform rate to room temperature in 2 hours.

The reinforcements hereinbefore described are of the type that wear away as the wheel wears away. This feature is of importance, particularly in those applications that do not permit stopping the wheel to remove a portion of the reinforcement when the abrasive has worn to the diameter of the reinforcement.

One method of embedding the metal element or elements in the adhesive portion of the reinforcement comprises the use of two comparatively thin sheets of rubber compound instead of one relatively thick sheet. By this means a sheet of rubber may be applied to each wheel and the metal part or parts may be inserted between the coated faces of the wheels and another sheet of rubber compound. The curing operation is carried out as described above.

One method of providing a wheel of the type illustrated in Figures 2 and 3 comprises priming the abrasive faces with a plastic material consisting of, by way of example, 22% phenolic condensation resin in the B stage, 68% finely divid-

ed inert material, such as 220 mesh silicon carbide, and 10% of a solvent or plasticizer, such as furfural. This priming coat is worked into the surface pores of the abrasive face by means of a stiff putty knife or other suitable instrument in order to provide good contact between the plastic material and the bonded abrasive. The primed surface then is covered with plastic material. Continuous steel rings of the desired cross-sectional area and diameter then are pressed into the plastic material in concentric relationship to the wheel and to each other, and covered with plastic material.

The plastic material is then cured under pressure at a temperature that is consistent with the requirements of the particular material used and that will not set up undue stresses in the bonded abrasive. When the curing of the reinforcement is complete the wheel is cooled slowly to ordinary temperature. A uniform temperature drop of 2° F. per minute has been found satisfactory, and is given by way of example.

The reinforcements shown in Figures 2, 3, 4, 5 and 6, which comprise metal elements joined to the bonded abrasive, do not wear away during the normal operation of the wheel. With the particular form of metal elements shown in Figures 2 and 3 reduction in size of the reinforcement is accomplished by removing one or more of the outer metal rings as required. This is done by cutting out or chipping out the embedding material and prying off the desired number of rings. The same general procedure is followed in reducing the number of turns in the spiral of Figure 4. The plate 8 of Figures 5 and 6 is reduced in diameter by cutting through the outermost band with a chisel and then removing said band by means of a slotted key. The band of metal is rolled up on the end of the key as it is torn from the wheel.

While the methods described above have been applied specifically to particular modifications as illustrated in the drawings, it will be recognized by those skilled in the art that the description applied to one illustration may be applied to another of the illustrations or to modifications not shown in the drawings.

Having thus described our invention, what we claim is:

1. An abrasive wheel having a metal disk of substantially the same diameter as the abrasive wheel attached to each lateral face of said abrasive wheel by a hard rubber composition.

2. A reinforced wheel of bonded abrasive material having reinforcing members which elongate less than the abrasive material does under the same stress, said members comprising metal rings embedded in a cement which adheres rigidly to the bonded abrasive, the elasticity of the cement being of a similar order of magnitude to that of the bonded abrasive.

3. An abrasive wheel construction including an abrasive wheel body and convolutions of wire secured to a face of the wheel, said convolutions being bonded to the face of the wheel by a layer of tough, plastic material cured or indurated under pressure.

4. An abrasive wheel having a lateral reinforcing member of vulcanized hard rubber compound intimately united to a side thereof, said abrasive wheel being under a compressive stress directed inwardly toward the rotative axis of the wheel and said lateral facing being under a tensile stress.

5. In the manufacture of abrasive wheels, the method of reinforcing the same against the centrifugal stresses of rotation which comprises mixing rubber and sulphur with a filler to provide a plastic composition which will cure to a solid with a coefficient of thermal expansion higher than but of the same order of magnitude as that of the abrasive wheel, coating the lateral faces of the abrasive with said plastic composition, heating the thus coated abrasive wheel to indurate the plastic material, and cooling the same after the plastic material has been cured, whereby the abrasive wheel will be subjected to a compressive stress directed toward its rotative axis and said lateral coatings will be subjected to a tensile stress.

6. An abrasive wheel having a lateral reinforcing member consisting of an intimate mixture of indurated organic material and granulated filler intimately united to each of the sides thereof, said abrasive wheel being under a compressive stress directed inwardly toward the rotative axis of the wheel and said lateral facings being under a tensile stress.

7. In the manufacture of abrasive wheels, the method of reinforcing the same against the centrifugal stresses of rotation which comprises mixing a heat hardenable organic plastic material with a filler to provide a plastic composition which will cure to a solid with a coefficient of thermal expansion higher than but of the same order of magnitude as that of the abrasive wheel, coating the lateral faces of the abrasive with said plastic composition, heating the thus coated abrasive wheel to cure the plastic material, and cooling the same after the plastic material has been cured, whereby the abrasive wheel will be subjected to a compressive stress directed toward its rotative axis and said lateral coatings will be subjected to a tensile stress.

8. In the manufacture of abrasive wheels, the method of reinforcing the same against the centrifugal stresses of rotation which comprises mixing a phenolic condensation resin with a filler to provide a plastic composition which will cure to a solid with a coefficient of thermal expansion higher than but of the same order of magnitude as that of the abrasive wheel, coating the lateral faces of the abrasive with said plastic composition, heating the thus coated abrasive wheel to indurate the plastic material, and cooling the same after the plastic material has been cured, whereby the abrasive wheel will be subjected to a compressive stress directed toward its rotative axis and said lateral coatings will be subjected to a tensile stress.

9. An abrasive wheel having a metal disk attached to each lateral face thereof by cement containing a phenolic condensation resin and granulated filler in sufficient proportion to modify the character of the resin whereby the said cement has a higher modulus of elasticity than the said abrasive wheel.

10. An abrasive member having an abrasive body of bonded abrasive grains, a rigid backing support therefor, and an intermediate layer of hard rubber containing at least twenty per cent by weight of sulphur vulcanized therebetween and permanently securing the abrasive body and backing support together as an integral unit.

11. An abrasive wheel having a reinforcing member comprising a metal disc and a body of hard rubber compound intimately united to a lateral face of the said wheel by intimate union of the said rubber compound with the said lat-

eral face of the wheel and with the said metal disc.

12. An abrasive wheel construction including an abrasive wheel body and a reinforcing member comprising an intimate mixture of organic material and granulated filler intimately united to a side of the said wheel whereby the strength of the said reinforcing member supplements the strength of the said abrasive wheel body, said mixture having a coefficient of expansion and a modulus of elasticity of the same order of magnitude but higher than those of the abrasive wheel body.

13. An abrasive wheel construction including an abrasive wheel body and a reinforcing member comprising an intimate mixture of organic material and granulated filler intimately united to a side of the said wheel whereby the strength of the said reinforcing member supplements the strength of the said abrasive wheel body, said reinforcing member having a modulus of elasticity of the same order of magnitude but higher than that of the abrasive wheel body whereby the abrasive wheel construction is capable of withstanding greater centrifugal stress than the abrasive wheel body alone.

14. An abrasive wheel construction including an abrasive wheel body and a reinforcing member comprising an intimate mixture of indurated synthetic resin and granulated filler in sufficient pro-

portion to modify the character of the resin whereby the said reinforcing member has a higher modulus of elasticity than the said abrasive wheel body, the said reinforcing member being intimately united to the said abrasive wheel body whereby the strength of the reinforcing member supplements the strength of the said abrasive wheel body.

15. An abrasive wheel construction including an abrasive wheel body and a reinforcing member comprising an intimate mixture of indurated phenolic condensation resin and granulated filler in sufficient proportion to modify the character of the resin whereby the said reinforcing member has a higher modulus of elasticity than the said abrasive wheel body, the said reinforcing member being intimately united to the said abrasive wheel body whereby the strength of the reinforcing member supplements the strength of the said abrasive wheel body.

16. An abrasive wheel construction including an abrasive wheel body and a reinforcing member having a greater unit strength than the said abrasive wheel body and comprising an intimate mixture of a hard rubber compound and granulated filler intimately united to a side of the said abrasive wheel body.

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