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REINFORCED ABRASIVE ARTICLE AND METHOD OF MAKING SAME

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Fig. 1.

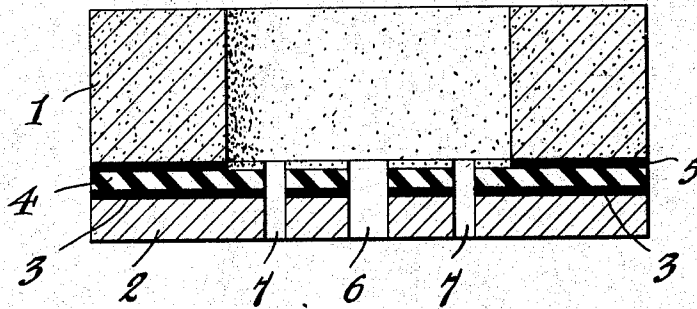
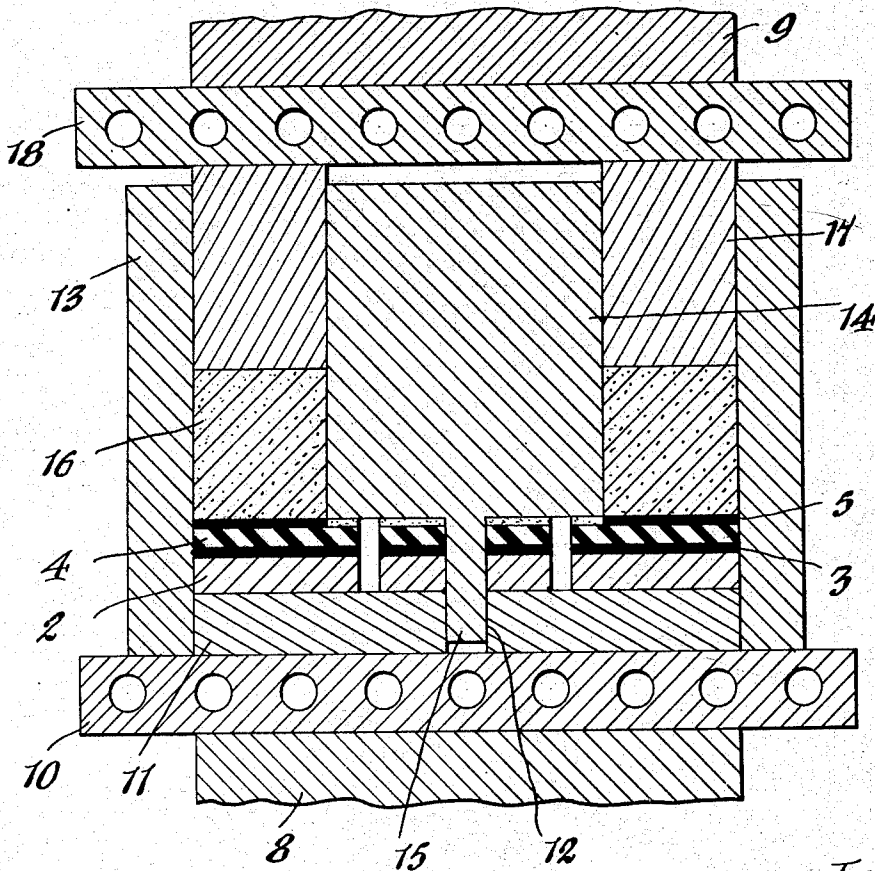


Fig. 2.



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REINFORCED ABRASIVE ARTICLE AND
METHOD OF MAKING SAME

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7 Claims. (Cl. 51-209)

This invention relates to bonded abrasive articles and the method of making same. More particularly it relates to abrasive articles in which the abrasive portions of the articles are supported by rigid means, such as backing plates or side plates secured to the flat face of the abrasive sections and to methods of molding the abrasive portions and securing them to the rigid reinforcing means. The invention has as an object the making of a superior reinforced abrasive article able to withstand very severe usage and to a novel method of making such article distinguished by its economy and ease of practice. Other objects of the invention will become apparent as the description proceeds.

It is common in the art in the making of disc shaped grinding wheels adapted to be mounted for grinding with the flat side face of the wheel to employ a rigid metal supporting and reinforcing plate secured to one flat side face of the wheel as by being adhesively mounted thereon with a resilient tie bond interposed between the backing plate and the abrasive. Such resilient tie bond, which is most commonly made of rubber, is necessary in such construction because of the great difference in coefficient of expansion of the backing plate and the abrasive and also because of the necessity of cushioning the abrasive portion from shocks which might be transmitted to it from a rigid reinforcing plate. The yieldable tie bond provides such necessary cushioning effect and allows differential expansion between the backing and the abrasive which otherwise would impose severe stresses upon the abrasive and might ultimately result in the fracture thereof.

In the making of such prior art reinforced abrasive articles such as disc shaped grinding wheels, the abrasive portions have been molded and the bond has been vitrified, in the case of ceramic bonded abrasives, and cured in the case of abrasive portions bonded with organic binders such as rubber, synthetic resins, or shellac. The thus preformed abrasive body has then been mounted upon the reinforcing backing. This has been done by suitably cleaning and preparing the face of the abrasive to be secured to the backing, and by preparing the backing for its reception. The latter is straightened, the surface thereof to be secured to the abrasive is sand-blasted, and the backing is again straightened. The abrasive, a layer of tie bond, and the reinforcing backing, with or without added layers of suitable cement between metal backing and tie bond and tie bond and abrasive are then assembled in that order

and the assembly subjected to heat and pressure for a sufficient length of time to effect the cure and vulcanization of the tie bond and the cure and hardening of the added layers of adhesive, if such are employed. A reinforced bonded abrasive article made in this manner requires extensive finishing steps after the above described process of bonding the abrasive to the reinforcing plate. In such finishing operation the assembled wheel is mounted on a lathe by means contacting the center arbor hole in the backing plate, and by use of suitable cutting or dressing tools the various grinding surfaces of the wheel are finished to size and are located in the desired relationship with reference to the backing plate. Such steps are necessary because it is not possible by use of production methods to assemble an abrasive article on a backing plate so that all of its surfaces bear the correct relationship to the backing plate, even though the abrasive article were initially finished to the desired shape and size.

By use of the method of the present invention a wheel stronger, safer, and otherwise superior to that made by prior art methods is produced. In addition, such method obviates the use of several steps necessary in the prior art, and in so doing cuts down the cost of the finished article to a marked extent. Furthermore, by practice of the present invention it has been found that the number of finished wheels having cracked abrasive sections and other defect rendering them useless is much less than that resulting from prior art methods.

Briefly, the method of the present invention consists in assembling upon a reinforcing plate, whose bonding surface has been suitably prepared, a layer of unvulcanized tie bond both of whose surfaces may have been coated with suitable adhesives. On the top of the upper surface of the tie bond there is placed a suitable amount of an intimate mixture of abrasive grain and a relatively low temperature cure binder such as rubber, synthetic resin, or shellac. Such mixture is then subjected to pressure so that it is compacted and brought to the desired shape, and the whole assembly is then heated for such length of time as to cure the abrasive bond, vulcanize the tie bond, and, if added adhesive is employed on the tie bond between it and the abrasive and between it and the backing, to cure such adhesive layers. The composition of the tie bond used is such that it is tough and resilient after the prolonged heating between approximately 300 and

400° F. which is necessary to cure the abrasive bonds employed.

The invention will be more readily understood by reference to the accompanying drawing in which Figure 1 is a view in cross section of a reinforced abrasive article made in accordance with the present invention; and

Figure 2 is a view in cross section of apparatus by which the molding and/or subsequent heat treatment of the assembled reinforced wheel may be carried out.

The abrasive article shown in Figure 1 by way of illustration consists of a bonded abrasive annulus 1, secured to a reinforced backing plate 2. Plate 2 may be made of iron, steel or other suitable metal. Backing plate 2 may also, if desired, be made of other material, such as a molded resin, which has sufficient strength and shock resistance in the particular wheel in which it is employed, and which also has sufficient resistance to heat that it is not materially affected by the heating necessary to cure the abrasive bond and vulcanize the tie bond. Backing member 2, in the modification shown in Figure 1, is secured to abrasive annulus 1 by means of interposed layers of cement 3, resilient tie bond 4, and layer of cement 5, occurring in the finished article in the direction from backing 2 toward abrasive 1 in the order named. Backing member 2 is provided with a central hole 6 therein for the reception of the arbor of the grinding machine, and with holes 7 for the reception of bolts holding the wheel onto a mounting plate on the grinding machine.

In forming the abrasive article of Figure 1, the apparatus shown in Figure 2 may be conveniently used. Such apparatus consists of a press, of which only portions of the bottom platen 8 and the top press plunger 9 are shown in the figure. A hot plate 10 is placed on top of platen 8 and on top of hot plate 10 there is placed a mold assembly consisting of a bottom plate 11 having a central hole 12 therethrough, and a mold barrel 13 surrounding the bottom plate. A backing plate 2, having its top surface suitably prepared and coated with a layer of adhesive 3, and having a sheet of resilient tie bond 4 of the required shape and size positioned thereon, the upper surface of the tie bond being coated with a layer 5 of adhesive, is then placed within mold barrel 13 on top of mold plate 11. Interior mold part 14, which is in the nature of a core, and which has on its bottom end a centrally projecting pin 15, is then introduced into the assembly so that pin 15 fits into hole 12.

A suitable amount of an intimate mixture 16 of abrasive grain and low temperature cure bond, such as a synthetic resin, is then introduced into the mold in the space between mold barrel 13 and core 14 and is distributed so as to have a maximum uniformity as regard to degree of compaction and the height to which it extends above adhesive layer 5 at every location within the mold. Plunger 17, which is in the form of an annulus having inner and outer diameters such as the annulus fits the space between mold barrel 13 and core 14 within close tolerances, is then assembled in the mold. The upper hot plate 18 is placed on top of mold part 17, and press plunger 9 is then brought down under a predetermined pressure to compact the mixture 16 of grain and bond to a predetermined degree and to force it firmly against layer 5 of adhesive, which in turn, together with tie bond 4 and layer of adhesive 3 are firmly compressed in the direction toward the backing plate 2. Such initial compression may take place

either in the cold, in which case hot plates 10 and 18 act merely as spacers for the time being or, if desired, the initial compacting may take place with the parts in heated condition, the heat being supplied by circulating steam through the bores within the hot plates.

After the assembly has been initially compressed either in hot or cold condition, it is then subjected to heat for a suitable length of time to cure the bond for the abrasive, the tie bond, and the adhesive layers, thus uniting the backing plate, tie bond, and bonded abrasive portions of the article intimately into a unitary structure. The last recited heating step for the purpose of curing tie bond and abrasive bond may be, if desired, carried out in the same press which was employed for the initial pressing step, or, alternatively, the mold may be removed from the press and heated, for instance, by being charged into an oven. The wheel may be removed from the mold and open cured, in which case it may be supported by sand, or buried in sand or other material if desired. It is sometimes desirable to maintain the assembly under moderate compacting pressure during the cure; this may be accomplished in the press, or if the cure takes place in an oven, by suitable weights or clamps on the mold or wheel.

The following example, which is illustrative only, is typical of procedures followed and compositions of the materials employed in carrying out the present invention:

A steel reinforcing backing is straightened and is cleaned and sand-blasted on that side which is to be secured to the tie bond. The sand-blasted surface is then coated with a cement having good adhesive properties for the backing plate and the type of tie bond employed. In this instance the cement used on the steel backing consists of the following ingredients in the indicated ratios:

Phenol formaldehyde resin such as "Bake-lite" resin BR2417	grams	25.0
Ethyl sulfate	cc	16.6
1-chloro-1-nitropropane	cc	4.2
Methyl ethyl ketone	cc	67.0
o-Dichlorobenzene	cc	22.0
Compound X	grams	10.0

Compound X consists of the following ingredients in the indicated ratios:

	Grams
Hycar OR-15	100.0
Soft carbon black	50.0
ZnO	5.0
Phenyl-beta-naphthylamine	1.0
Nevoll	15.0
Benzothiazyl disulfide	1.25
Sulfur	40.0
	212.25

"Hycar O. R." is a synthetic rubber composed of a copolymer of butadiene with acrylic acid nitrile.

Nevoll is a liquid coal tar derivative having a specific gravity of approximately 1.10, which functions as a rubber softener and dispersing agent.

Such coated backing plate has then placed upon it a layer of resilient tie bond material, which is usually $\frac{1}{8}$ to $\frac{1}{4}$ of an inch in thickness. Such tie bond, which may be provided with a plurality of perforations extending therethrough in accordance with the teaching of application Serial No. 492,057, filed June 24, 1943, by Arthur G.

Scutt, or which may be imperforate, in this instance consists of a material known as "Ameripol" which is essentially the same as "Hycar O. R." "Hycar O. R.," as explained above, is a copolymer of butadiene with acrylic acid nitrile. The tie bond has its bottom surface cleaned, and its top surface cleaned and covered with a layer of a cement which has been found suitable for bonding the tie bond to the mixture of abrasive grain and organic bond. Such cement is one consisting of 75% of a liquid phenol-aldehyde condensation product such as "Bakelite" resin BC5763 with 25% of a finely divided clay added as a filler. The cement mixture may be thinned if necessary with a small amount of a resin solvent such as furfural or alcohol. The tie bond thus coated on its top surface and cleaned on its bottom surface is placed on the top cement coated face of the backing, and the backing plate with the attached tie bond is placed in the mold with the backing plate on the bottom.

A suitable amount of a mixture of grain and low temperature cure bond is then charged into mold space lying between core 14 and mold barrel 15. Such abrasive-bond mixture may be prepared in accordance with Martin Re. Patent No. 19,318. In accordance with this method a predetermined amount of abrasive grain of suitable mesh size is wet with a relatively small amount of resin solvent which may be, for example, furfural. The thus treated grain is then mixed with a suitable quantity of a powdered synthetic resin, such as an A stage phenol-aldehyde condensation product, in the amount, for example, of 10% by weight of the mixture. The ingredients are mixed quickly to keep the mix from balling up, after which the mixture is ready for charging into the mold. After such step, the mold is closed by having plunger 17 placed thereon, and the assembly is cold pressed at, for example, a pressure of 2000 pounds per square inch of abrasive mix. The resin abrasive bond, cement layers, and tie bond are then removed from the mold and cured by heating the assembly under a moderate pressure for a maximum of 55 hours, 46 hours of such period being consumed in raising the temperature to approximately 400° F. After a hold of 9 hours at this temperature, the wheel assembly is cooled in stages to room temperature. With the exception of a slight dressing operation necessary to remove the outer glaze from the grinding surface, the wheel is in wholly finished condition after its cure.

It is to be understood that the procedure set out in the above example is capable of numerous variations. It is possible to employ the tie bond alone without layers 3 and 5 of cement thereon to secure the abrasive to the backing. It is also possible to employ the first named cement, namely, that employing as an ingredient thereof "Hycar O. R. 15," for both the cement between the backing and the tie bond and that between the tie bond and the abrasive. It is also possible to employ for both these layers of cement the composition composed of a liquid phenol-aldehyde condensation product such as "Bakelite" resin B. C. 5763 with 25% added filler. Other cements besides those above specifically mentioned may be used for these layers. Such cements must have satisfactory hot and cold strengths when employed between the specific elements to be adhered together, and must possess sufficient heat resistance so as not to be deleteriously affected to any marked extent when

heated to such temperatures and for such lengths of time as are necessary to cure the abrasive bond and the tie bond.

Instead of the "Ameripol" tie bond above disclosed, one made of Buna S, which is a copolymer of butadiene and styrene, may be used. Buna S may be cured at the same temperature as "Ameripol," and has substantially the same qualities insofar as strength and resilience are concerned. Buna S, however, is not oil resistant, and so unless protected by an oil resistant coating it is not advisable to employ it in wheels which are to be used with oily grinding fluids. Other elastomers, synthetic or natural, may also be employed as the tie bond in the wheel. Such elastomers must, like the cement layers, have adequate hot and cold strength and not be adversely affected by the curing treatment employed for the abrasive bond. The molding pressure used is capable of variation, the particular one employed being that yielding the desired grade of wheel.

Besides the synthetic resin bond employed for the abrasive in the example above, other low temperature bonds such as natural rubber, synthetic rubber, and shellac may be employed, all of which have a curing temperature of approximately 325° F. If a natural rubber or natural rubber compound were employed as the tie bond with the above abrasive bonds, it would as a result of heating at approximately 325° F., be cured to a hard inflexible condition, but a tie bond composed either of "Ameripol" or Buna S remains sufficiently resilient after such heat treatment so that it will perform its intended function. When shellac is used as the bond for the abrasive the preparation of the abrasive-bond mixture and the molding thereof may conveniently be carried out in accordance with the disclosures of the Martin Patents Re. 17,739 and Re. 17,740. A typical curing cycle for the resulting molded abrasive shellac mixture, the cement layers, and the tie bond consists of heating the wheel assembly to a temperature of approximately 325° F. for a period of 6 days.

Reinforced abrasive articles coming within the scope of this invention, for example, disc shaped grinding wheels, are distinguished from prior art reinforced abrasive articles by their strength and safety. Because the molding of the abrasive and the compacting of such abrasive, the resilient tie bond, and the intermediate layers of cement, if such are used, against the rigid backing all take place at the same time, the maximum possible strength is developed at each interface. The bond employed for the abrasive and the cement layer on the top of the resilient tie bond mingle at the interface and become practically one. The abrasive granules when compacted against such upper cement layer and/or the tie bond are free to adjust themselves under the relatively high pressure employed, e. g. 2000 p. s. i., and thus assume positions where they are most intimately in contact with the upper cement layer and/or the tie bond. At the same time the tie bond and cement, if such is used, flow under the pressure into the most intimate contact with the abrasive mix. A wheel made in this manner has the grit at the bottom of the abrasive slightly out of a plane, because of the self-adjustment of the abrasive mix and tie bond. This contrasts with a premolded and cured abrasive wherein the face adjacent the tie bond lies in a plane, since it was in contact with plane faces of the mold. The abrasive portion of the present wheel is thus

keyed to the tie bond much more thoroughly than that in prior art wheels.

This becomes apparent when prior art processes are considered. In making reinforced wheels by premolding and curing the abrasive portion and then securing it to a backing by means of an interposed tie bond, only moderate pressures can be employed to press the abrasive against the tie bond and the tie bond against the backing. The pressure employed in this process is limited to a value not materially above 300 p. s. i. by the fact that the prebonded abrasive is readily broken under pressure, particularly if it is slightly warped, and by the fact that higher pressures result in the extrusion of the tie bond from the wheel assembly to an undesirable extent. The use of a mold surrounding the assembly to prevent such extrusion is not feasible because of the practical impossibility of finishing the abrasive portion to sufficiently close tolerances to allow it to seal the mold against such extrusion of the tie bond. Because of the inherent limitation of the former method to the use of low pressures for effecting assembly of the parts, the bonds between the wheel parts are relatively weak compared with those obtained by practice of the present invention.

The reinforced wheel resulting from the present invention shows resistance to breaking which is much superior to that of any similar wheel made by prior art methods. When speeded to destruction after the abrasive had been cut through by four radial slots spaced 90° from each other, a typical wheel of the present invention did not fail until it reached a surface speed of 25,000 feet per minute. This is much in excess of breaking speeds reached by reinforced wheels made by premolding the abrasive and then securing it to a backing, and still further exceeds the minimum breaking surface speed per minute, imposed by safety requirements, for this type of wheel.

The method of the present invention shows marked advantages over prior art methods in that by its use fewer operating steps are necessary to produce a finished wheel. Molding of the abrasive portion takes place simultaneously with mounting of the backing and the resilient tie bond. Thus the separate preparation and finishing of the abrasive are avoided. Furthermore, except for the light dressing above noted no finishing of the abrasive, after the assembly has been finally mounted and the parts cured, is necessary. On the other hand, when the abrasive is molded and cured separately and then is mounted upon the backing plate with an interposed tie bond, it is necessary to finish the abrasive extensively to locate all its surfaces in the desired relationship with respect to the backing and to bring the wheel to final balance. The method of the present invention is flexible, since within the limits of compositions of tie bond, cements, and abrasive bonds noted above, the same steps are followed regardless of what different compositions of such parts are employed.

While the preferred embodiment of the reinforced abrasive article and its process of manufacture have been described above in detail, it is to be understood that the invention is not limited to all of the described details, but that it may be otherwise embodied within the scope of the following claims.

I claim:

1. The method of making reinforced abrasive articles comprising pressing a mixture of abra-

sive grain and low temperature cure bond onto a layer of substantially uncured tie bond comprising an elastomer in sheet form which is vulcanizable to a permanently tough and resilient condition mounted on a strong rigid reinforcing backing, and heating the assembly of backing, tie bond, and molded abrasive until the abrasive bond becomes hard and relatively inflexible and the tie bond becomes cured and bonded to the abrasive and the backing but remains tough and resilient.

2. The method of making reinforced abrasive articles comprising preparing a mixture of abrasive grain and a bond therefor having a curing temperature lying between 300 and 400° F., pressing and molding such mixture of grain and bond onto a layer of substantially uncured tie bond comprising an elastomer in sheet form which is vulcanizable to a permanently tough and resilient condition assembled on a strong rigid backing plate, such molding and pressing serving to compress the abrasive grain and bond strongly against the tie bond and the backing plate, and heating the assembly of backing plate, tie bond, and abrasive at temperatures between 300 and 400° F. until the abrasive bond becomes cured to a hard and relatively inflexible condition and the tie bond becomes cured and bonded to the abrasive and backing plate but remains tough and resilient.

3. The method of making reinforced abrasive articles comprising preparing a mixture of abrasive grain and a bond therefor curable at temperatures between 300 and 400° F., pressing and molding the mixture of abrasive grain and bond onto a layer of substantially uncured tie bond in sheet form comprising a copolymer of butadiene and a copolymerizable resin assembled on a strong rigid reinforcing backing, said tie bond being vulcanizable to a permanently tough and resilient condition, and heating the assembly of backing, tie bond, and molded abrasive at temperatures between 300 and 400° F. until the abrasive bond becomes cured to a hard and relatively inflexible condition and the tie bond becomes cured and bonded to the abrasive and the backing but remains tough and resilient.

4. The method of making reinforced abrasive articles comprising preparing a mixture of abrasive grain and a bond therefor curable at temperatures between 300 and 400° F., pressing and molding such mixture of abrasive grain and bond onto a substantially uncured layer of tie bond in sheet form, such tie bond comprising a copolymer of butadiene with acrylic acid nitrile and being vulcanizable to a permanently tough and resilient condition, said tie bond being assembled on a strong rigid backing plate, and heating the assembly of backing plate, tie bond, and molded abrasive at temperatures between 300 and 400° F. until the abrasive bond becomes cured to a hard relatively inflexible condition and the tie bond becomes cured and bonded to the abrasive and the backing plate but remains tough and resilient.

5. The method of making reinforced abrasive articles comprising preparing a mixture of abrasive grain and a bond therefor curable at temperatures between 300 and 400° F., pressing and molding such mixture of abrasive grain and bond onto a substantially uncured layer of tie bond in sheet form, such tie bond comprising a copolymer of butadiene with styrene and being vulcanizable to a permanently tough and resilient condition, said tie bond being assembled on a strong rigid

backing plate, and heating the assembly of backing plate, tie bond, and molded abrasive at temperatures between 300 and 400° F. until the abrasive bond becomes cured to a hard relatively inflexible condition and the tie bond becomes cured and bonded to the abrasive and the backing plate but remains tough and resilient.

6. The method of making reinforced abrasive articles comprising preparing a mixture of abrasive grain and a synthetic resin bond, pressing and molding the mixture of abrasive grain and bond onto a layer of substantially uncured tie bond vulcanizable to a permanently tough and resilient condition and comprising a copolymer of butadiene and a copolymerizable resin in sheet form assembled on a strong rigid reinforcing backing, and heating the assembly of backing, tie bond, and molded abrasive for a period of at least 50 hours, a substantial portion of the heating cycle being carried out at a temperature between 325° and 400° F., and then cooling the article, the heating cycle being such that the abrasive bond becomes cured to hard and relatively inflexible

condition and the tie bond becomes cured and bonded to the abrasive and the backing but remains tough and resilient.

7. The method of making reinforced abrasive articles comprising preparing a mixture of abrasive grain and a shellac bond, pressing and molding the mixture of abrasive grain and bond onto a layer of substantially uncured tie bond vulcanizable to a permanently tough and resilient condition and comprising a copolymer of butadiene and a copolymerizable resin in sheet form assembled on a strong rigid reinforcing backing, and heating the assembly of backing, tie bond, and molded abrasive for a prolonged period, a substantial portion of the heating cycle being carried out at a temperature of at least 325° F., and then cooling the article, the heating cycle being such that the abrasive bond becomes cured to a hard and relatively inflexible condition and the tie bond becomes cured and bonded to the abrasive but remains tough and resilient.

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