Patented Sept. 11, 1945

2,384,684

UNITED STATES PATENT OFFICE

2,384,684

GRINDING WHEELS

Samuel S. Kistler, West Boylston, Mass., assignor to Norton Company, Worcester, Mass., a corporation of Massachusetts

No Drawing. Original application May 31, 1940, Serial No. 338,039. Divided and this application October 13, 1942, Serial No. 461,893

6 Claims. (Cl. 51—299)

The invention relates to grinding wheels having organic bond. This application is a division of my application, Serial No. 338,039, filed May 31, 1940.

One object of the invention is to provide a resilient grinding wheel. Another object of the invention is to provide a rigid grinding wheel of superior qualities for certain snagging operations. Another object of the invention is to provide a grinding wheel for snagging operations of longer life without loss of quality as determined by wheel wear and material removed. Another object of the invention is to provide a bond for grinding wheels having some of the characteristics of natural rubber without its variations in quality. Another object of the invention is to provide a bond for grinding wheels having high heat resistance.

Another object of this invention is to facilitate, for achieving such objects as those above noted, the use of certain synthetic rubbers and also to provide a simple and dependable method and means for rendering them more readily workable for the achievement of such objects as the aforesaid. Another object is to provide a method for better controlling, in the making up of grinding wheels or the like, such synthetic rubbers as above mentioned, and for facilitating the variation, according to the intended use or purpose of the grinding wheel, of the characteristics of the ultimate grinding wheel structure. Another object is to provide a grinding wheel utilizing rubber, that is, so-called natural rubber, but in smaller quantities than heretofore and yet achieve certain desired grinding wheel characteristics.

Other objects will be in part obvious or in part pointed out hereinafter.

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

I have found that polymeric butadiene with sulphur makes an excellent bond for abrasive grains to form grinding wheels having some of the characteristics of rubber but many superior features. I have also found that copolymers of butadiene and acrylic nitrile with sulphur are useful for this purpose. Methyl acrylic nitrile may be substituted for acrylic nitrile. I have further found that the copolymer of butadiene and styrene is useful for the manufacture of grinding wheels.

Butadiene is a hydrocarbon of the formula,

$$CH_2=CH-CH=CH_2$$

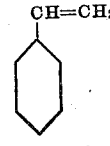
Butadiene is considered to polymerize in a linear chain. Acrylic nitrile may be also termed vinyl cyanide and is written,

$$CH_2=CH-CN$$

Methyl acrylic nitrile may be written,

$$CH_2=C(CH_3)-CN$$

and has properties similar to acrylic nitrile. It may be termed methyl vinyl cyanide. Styrene is written,



and may be termed vinyl benzene. Thus all three of acrylic nitrile, methyl acrylic nitrile and styrene have a vinyl or a substituted vinyl group. These substances link together with butadiene in the chains and together form a linear polymer. When sulphur is added, however, and the compound is vulcanized, there is a cross linking more or less, depending upon the amount of sulphur used. The butadiene polymers, whether butadiene alone or combined with acrylic nitrile, methyl acrylic nitrile or styrene, are thermoplastic until vulcanized with sulphur. When so vulcanized, they have more or less rigidity, depending upon the amount of sulphur incorporated into the mix. All of these substances are compatible with natural rubber and may be vulcanized with it to form a resilient or soft rubbery substance or a hard ebonite-like substance, depending upon the amount of sulphur used. The polymerization or copolymerization with sulphur is achieved by the use of heat and may be termed vulcanizing.

The polymers of butadiene and butadiene with acrylic nitrile are collectively known by the trade-mark "Buna" rubber, and a specific copolymer of butadiene and acrylic nitrile is known by the trade-mark "Perbunan." This may be mixed with sulphur and abrasive grains on the mill, formed into sheets from which blanks can be died out, pressed and vulcanized to form grinding wheels. The preferred procedure is as follows:

"Perbunan," which comes in the form of rubbery chunks like smoked sheets pressed together, is passed between heavy rolls to plasticize it and

as this is done the required amount of sulphur, filler, accelerator and abrasive is added, the mixture being passed back and forth between heavy rolls to break down the Perbunan and mix it thoroughly with the other substances. When the mix becomes plastic and workable according to the standards known for the manufacture of rubber bonded grinding wheels, a quantity of the mixture is passed between a pair of rolls set closely together to form a sheet, blanks are died out, a number of the blanks placed in a mold, the mold is placed in a hot press, and the mixture is vulcanized therein. As a specific example of the foregoing, I may make a mixture in the manner described, of the following ingredients:

Example I

Ingredient	Parts by weight
Abrasive (e. g., Al_2O_3 or SiC)	200
"Perbunan"	100
Sulphur	3
"Spheron" black (finely divided carbon)	70
"Altax" (disulphide of mercapto benzo thiosol)	1.5
Dibutyl amine	.25
Zinc oxide	5
Stearic acid	1.5
Coal tar	5
Rosin	5

In the foregoing the abrasive may be in any grit size desired, depending upon the proposed use for the grinding wheel. The carbon in comminuted form ("Spheron" black) is a standard filler for rubber products and makes the final product relatively stiff and tough. The "Altax" is a high temperature accelerator, the dibutyl amine is a booster accelerator, the zinc oxide is an activating filler, the stearic acid is a stabilizer, and the coal tar and rosin help in handling the product on the mill.

Grinding wheels made with the ingredients of Example I according to the method heretofore outlined are resilient due to the small amount of sulphur, that is to say, readily deformable. Nevertheless this resiliency does not approach extreme flexibility; the product is also fairly tough. One important feature of the wheel of Example I is that it is very strong. Soft rubber bonded wheels have been too weak and frequently burst. Wheels according to the present invention can stand an angular velocity as high as 12,000 surface feet per minute. Roughly speaking, the bursting stress of a wheel due to centrifugal force is constant per unit of diametrical cross section for a given velocity measured in surface feet per minute at the periphery regardless of the actual diameter of the wheel within certain limits. Eight thousand surface feet per minute is adequate for many practical grinding operations. A resilient or flexible rubber grinding wheel of the same elastic limit as the wheel of Example I would not withstand an angular velocity equal to 12,000 surface feet per minute. The grinding wheel made according to Example I is sufficiently deformable so that reentrant angles in a piece of steel can readily be ground and all sorts of dies, fixtures, automobide parts, etc., can be ground that could not be ground with a rigid grinding wheel without danger of taking off more metal in certain spots than might be desired. There is a real need for an effective grinding wheel which will conform to the work being ground and give a fairly uniform grinding action over an irregular surface and wheels made according to Example I fulfill this need.

As thus far described, particularly in Example I, I do not employ rubber, but in the examples later herein set forth I disclose, by way of illustration, how certain features and advantages of the foregoing may be carried out in combination with rubber and it is such combination that is claimed in this application.

The invention has also been embodied in rigid wheels, as follows:

Example II

Ingredient	Parts by weight
Fused alumina, No. 16 grit size	400
"Perbunan"	27.5
Rubber (smoked sheet)	27.5
Sulphur	18
Zinc oxide	25
Cryolite	15
Calcium oxide	5

In Example II the zinc oxide serves the same purpose as in Example I. The cryolite is a useful filler which improves the grinding action, while calcium oxide is a dehydrating agent to remove occluded water and prevent swelling during the cure. The method of procedure is the same as for the manufacture of a resilient rubber wheel excepting that vulcanizing may be carried out at 150° C. for eight hours.

Another grinding wheel was made as follows:

Example III

Ingredient	Parts by weight
Fused alumina, No. 16 grit size	400
"Perbunan"	13.75
Rubber	41.25
Sulphur	18
Zinc oxide	25
Cryolite	15
Calcium oxide	5

This wheel was compounded and cured the same as the wheel of Example II. For comparison purposes, a wheel was made like the wheel of Examples II and III but containing 55 parts of rubber with no "Perbunan." This wheel will be designated wheel A.

Still another wheel was made as follows:

Example IV

Ingredient	Parts by weight
Fused alumina, No. 16 grit size	400
"Perbunan"	22.5
Rubber	22.5
Sulphur	15
Cryolite	45
Zinc oxide	5
Calcium oxide	5

This wheel was similarly compounded and similarly cured.

Another wheel was made as follows:

Example V

Ingredient	Parts by weight
Fused alumina	400
"Purbunan"	11.25
Rubber	33.75
Sulphur	15
Cryolite	45
Zinc oxide	5
Calcium oxide	5

This wheel was compounded and cured the same

as each of the wheels of Examples II, III and IV and wheel A.

In working up, on the rolls of the mill, the mix according to Examples II, III, IV and V, the rubber gives to the mix and hence to the Perbunan a tackiness and workability in which the mix without the rubber is defective or deficient, and hence breaking down is materially speeded up.

Still another wheel was made like the wheel of Example V excepting that 45 parts of rubber was used instead of 11.25 parts of "Perbunan" and 33.75 parts of rubber. This wheel, hereinafter designated as wheel B, was made for comparison purposes.

As indicating the results of using "Perbunan," which as aforesaid, is a copolymer of butadiene and acrylic nitrile vulcanized with sulphur, in a grinding wheel, a comparison was made of wheels of Examples II to V inclusive and wheels A and B in a regular grinding test using a swing frame grinder. The wheels A and B are standard snagging wheels and both of them together with the wheels of Examples II to V inclusive were 16 inches in diameter by 2½ inches in thickness with a 6 inch central hole. The machine was a 16 inch swing frame grinding machine, the wheel speed for each wheel was adjusted to 9500 surface feet per minute, the pressure used was 130 lbs., the material was 18.8 Allegheny steel having a surface of 6" x 24", each run was fifteen minutes, there were five runs per wheel, and the grinding was done on the side with the wheel tilted. The results were as given in the following table:

Table I

Wheel identification	Wheel wear in cu. in. per hour	Material removed in lbs. per hour
Wheel A	49	22
Wheel of Example II	36.8	18.6
Wheel of Example III	41.2	19.5
Wheel B	50.0	22.4
Wheel of Example IV	31.0	17.4
Wheel of Example V	36.3	20.0

The quality of a grinding wheel depends upon many factors, and especially on what results are desired. It can be easily understood that if a given factory is getting the best results from a given grinding wheel and wages are doubled, a different grinding wheel may be desired. Using prevailing scales of wages and if overhead is 100% of labor, you can obtain a quality number for grinding wheels for snagging purposes by squaring the material removed and dividing by the wheel wear. However, probably because of labor differential and possibly for some other reasons, certain factories desire grinding wheels with a low rate of wheel wear. The above figures show that all of these wheels have quality numbers which may be tabulated as between 16 and 20 which is not too much difference. Specifically, the B quality numbers calculated by the above formula using a certain constant was as follows:

Table II

Wheel A	18
Wheel of Example II	17
Wheel of Example III	16
Wheel B	18
Wheel of Example IV	17
Wheel of Example V	20

The replacement of rubber, therefore, with "Perbunan" made little change in quality, it being seen that both the best and the worst wheel from the standpoint of quality number contained some "Perbunan." However, increasing amounts of "Perbunan," as shown in Table I, reduced the wheel wear. Grinding wheels with a low rate of wheel wear are definitely desired in many factories provided the amount of material removed does not drop too low. Accordingly for such purposes grinding wheels having butadiene products substituted for rubber in whole or in part are definitely found to be desirable and superior.

Another feature of butadiene products is that they have greater heat resistance than rubber products since vulcanized "Perbunan" softens at a higher temperature. Despite their many excellent qualities rubber bonded grinding wheels have been limited in their application by reason of the low thermal resistance of the rubber. Accordingly it is distinctly advantageous to produce a grinding wheel which has many of the characteristics of rubber bonded grinding wheels, the bond of which does not soften until temperatures higher than those which soften rubber bonds are reached.

I have discovered that one of the reasons for the excellent results often achieved with rubber bonded wheels is the presence of sulphur. Sulphur appears to have some action at the grinding line of a chemical nature which prevents loading. In particular, I believe that the presence of sulphur at the grinding line makes the ferrous metal chips brittle so that they do not load the wheel as readily as they otherwise would. Sulphur, therefore, appears to be an excellent filler for a grinding wheel for grinding ferrous metals. The presence of sulphur in rubber bonds was fortuitous and due to the fact that it was necessary to use sulphur to convert the rubber into a usable product. According to the present invention a compound is used which is also vulcanizable with sulphur but which, in having a higher thermal resistance than vulcanized rubber, is superior to rubber for many practical abrading purposes.

There may be enough occluded water in the butadiene products herein mentioned to cause some swelling during the cure. Calcium oxide CaO readily takes up water at temperatures above 100° C. and becomes converted to calcium hydroxide $Ca(OH)_2$. However, other dehydrating agents may be used, such as Activated Alumina, silica gel, and soluble anhydrite, $CaSO_4$.

It will thus be seen that there has been provided by this invention an article in which the various objects hereinabove set forth together with many thoroughly practical advantages are successfully achieved. As many possible embodiments may be made of the above invention and as many changes might be made in the embodiment above set forth, it is to be understood that all matter hereinbefore set forth is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. An abrasive product comprising abrasive grains distributed throughout and adhered and held together by a bond that comprises the vulcanized reaction product with sulphur as a vulcanizing agent of a mixture of a butadiene compound selected from the group consisting of (1) butadiene polymer and (2) butadiene copolymer comprising butadiene copolymerized with a vinyl compound, and unvulcanized natural rubber initially present in an amount to overcome, during working, the characteristic of the butadiene compound in resisting envelop-

ment of and adhesion to the abrasive grains and thereby to contribute grain-retentive plasticity thereto, whereby the bond effected by the aforesaid vulcanized reaction product substantially uniformly envelops and securely holds said abrasive grains.

2. In a method of making an abrasive article, the steps which comprise milling a butadiene compound selected from the group consisting of (1) butadiene polymer and (2) butadiene copolymer comprising butadiene copolymerized with a vinyl compound, together with a quantity of unvulcanized natural rubber to lessen the resistance of the butadiene compound to the inclusion therein and the adhesion thereby of abrasive grain and thereby condition the mix for the reception and retention therein of abrasive grain, admixing therewith abrasive grain to become substantially uniformly distributed throughout the mix and to prepare the mix for shaping without mechanical disintegration and loss of abrasive grains therefrom, together with a vulcanizing agent which includes sulphur whereby the abrasive grains are enveloped by and retained in the mix, shaping the resultant mix, and heat-treating to effect vulcanization of the admixed natural rubber and butadiene compound to thereby set the bonding of the abrasive grains and secure them in place to function as abradants.

3. In a method of making an abrasive article, the steps which comprise mixing a quantity of unvulcanized natural rubber into a quantity of polymerized butadiene compound for the purpose of giving the latter improved workability and tackiness for the reception thereinto and retention therein of abrasive grains and admixing therewith abrasive grains to become substantially uniformly distributed throughout the mix and held therein by the tackiness of the mix and to prepare it for shaping without mechanical disintegration, together with a vulcanizing agent that comprises sulphur, the latter in quantity sufficient to effect subsequent vulcanization under heat treatment of the intermixed buadiene compound and the rubber, shaping the resultant mix, and then heat treating the shaped mix to effect substantially concurrent vulcanization of the intermixed butadiene compound and rubber and thereby form a bonded body for holding and bonding the abrasive grains.

4. An abrasive product comprising abrasive grains distributed throughout and adhered and held together by a bond that comprises the vulcanized reaction product with sulphur as a vulcanizing agent of a mixture of butadiene copolymerized with acrylic nitrile and unvulcanized natural rubber initially present in an amount to give the butadiene copolymer improved workability and tackiness and thereby mitigate, during working, the characteristic of the butadiene copolymer in resisting envelopment of and adhesion to the abrasive grains and thereby to contribute grain-retentive plasticity thereto, whereby the bond effected by the aforesaid vulcanized reaction product substantially uniformly envelops and securely holds said abrasive grains.

5. An abrasive product comprising abrasive grains distributed throughout and adhered and held together by a bond that comprises the vulcanized reaction product with sulphur as a vulcanizing agent of a mixture of butadiene copolymerized with methyl acrylic nitrile and unvulcanized natural rubber initially present in an amount to give the butadiene copolymer improved workability and tackiness and thereby mitigate, during working, the characteristic of the butadiene copolymer in resisting envelopment of and adhesion to the abrasive grains and thereby to contribute grain-retentive plasticity thereto, whereby the bond effected by the aforesaid vulcanized reaction product substantially uniformly envelops and securely holds said abrasive grains.

6. An abrasive product comprising abrasive grains distributed throughout and adhered and held together by a bond that comprises the vulcanized reaction product with sulphur as a vulcanizing agent of a mixture of butadiene copolymerized with styrene and unvulcanized natural rubber initially present in an amount to give the butadiene copolymer improved workability and tackiness and thereby mitigate, during working, the characteristic of the butadiene copolymer in resisting envelopment of and adhesion to the abrasive grains and thereby to contribute grain-retentive plasticity thereto, whereby the bond effected by the aforesaid vulcanized reaction product substantially uinformly envelops and securely holds said abrasive grains.

SAMUEL S. KISTLER.