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ABRASIVE WHEEL AND METHOD OF MANUFACTURE

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This invention relates to an abrasive material, and particularly to abrasive wheels and the like.

The abrasive wheels now generally used in industry are artificially prepared. Such wheels are generally composed of an abrasive material held together by a fused bonding material or binder. When these wheels are used for grinding or abrading operations, as for example in grinding metal parts, the wheel itself by its use generates disruptive forces,—these forces being generally of two kinds, (*a*) those resulting from expansion and contraction of the wheel material due to temperature changes during use of the wheel, and (*b*) centrifugal forces due to rapid rotation of the wheel.

Considerable heat energy is generated at the zone of contact, as a result of the friction between the surface of the wheel and the metal or other part being worked. But abrasive wheels rotate at high velocity and the time during which any given portion of the wheel surface remains in contact with the work is very short. At the time of contact the generated heat energy tends to raise the temperature of the material composing the wheel, with attendant expansion. And the resulting expansion is irregular. This is due to varying temperatures of the wheel material which are present as the generated heat is conducted through the wheel material away from the zone of heat generation. Furthermore, the instant a given zone of contact moves out of contact with the work the heat energy impressed upon that zone is rapidly dissipated.

As a result, during use of an abrasive wheel the material of that wheel is subjected to rapidly succeeding temperature shocks; which in turn set up disruptive forces arising from within the wheel itself which tend to destroy the wheel.

An artificially prepared abrasive wheel consists generally of grains or particles of abrasive material, held together by a binder. This binder is usually a fused mass which, self contained within the wheel, holds the particles of abrasive material firmly, counteracting the disruptive or disintegrating tendencies arising within the wheel during operation. My work has led me to believe that the effective life of an abrasive wheel of this character is primarily dependent upon the degree of resistance of the binder to these disruptive or disintegrating forces. If that part of the binder lying along the periphery, or working surface, of the wheel disintegrates, or fritters away, if I may use that term, the grains or particles of abrasive material are thereby released and the wheel wears rapidly. Or if, due to unequal expansion of the wheel as a whole, or of a considerable portion of the wheel, a sufficiently powerful disruptive force is set up to crack the wheel, the result may be—under the influence of the centrifugal forces set up during rapid rotation of the wheel—complete destruction of the wheel, its disintegration as a whole.

One of the principal objects of the present invention is to provide an abrasive wheel which is free from the above described defects heretofore inherent in wheels of this character, and a method of making such a wheel.

Another object of the invention is to provide an abrasive wheel composed of such material that it has a negligible coefficient of expansion,—i. e. a coefficient of expansion insufficient to cause disruption of the material of the wheel during operation.

Other objects and advantages of the invention will be apparent from the description set out below.

While this invention is generally applicable to an abrasive body and to the method of making such an abrasive body; it is particularly applicable to ceramic abrasive wheels and for purposes of clearer description, and as setting out a preferred embodiment of the invention, it is described in connection with such a form of abrasive wheel as is generally used in industry.

The granules or particles of abrasive material may be of any suitable character, but in actual practice usually consist of emery, fused silicon carbide, fused aluminum oxide, or any desired mixture of these. These materials are crushed or ground to a desired size, are mixed with a suitable binding material and molded into the proper form. The mold-

ed forms are then dried, after which they are placed in a kiln and heated to a temperature sufficiently high to fuse the bonding material, but not sufficiently high to affect the abrading material. This bonding material may consist of any suitable compounds which will fuse at a sufficiently low temperature, and upon subsequent cooling will have suitable rigidity, strength, etc.

In practice the binder or bonding material is quite complex chemically; because it is generally not made from a mixture of chemically pure compounds, but rather from a mixture of several materials found in nature each of which is complex in character, being composed of a number of compounds. The bond heretofore has generally consisted of a mixture of compounds of the so called alkali and alkaline earth groups with certain other compounds such as oxides of silicon and aluminum. As an illustration the clay known commercially as "Albany slip", which is often used as one of the constituents of such a binder, has the following general analysis:—

	Per cent
Moisture	.052
Ignition loss	7.970
SiO_2	59.570
Al_2O_3	11.720
Fe_2O_3	5.240
FeO_2	.860
P_2O_5	.180
CaO	6.400
MgO	3.220
K_2O	2.680
Na_2O	.900
MnO	.460

Other constituents used are silica compounds, such as ball clay, feld-spar, and the like. These have substantially the same compounds as Albany slip but in different relative proportions. By properly admixing these several materials a binder of desired chemical constituency may be secured.

I have found that increasing the relative proportions of alkali compounds tends to increase the rate of fusion of the mass,—that is, the time interval necessary for accomplishing complete fusion at a given temperature—so much so in fact as to often cause objectionable frothing. Also increasing the proportion of alkali compounds tends to increase the coefficient of expansion of the resulting fused binder.

The akaline earths I have found tend to lower the coefficient of expansion. They also decrease the rate of fusion—giving a quiet and gradual fusion—often so affecting the rate of fusion that there is a lack of homogeneity in the fused binder which is very undesirable as it causes strains which greatly increase the destructive effect of temperature shocks.

Heretofore then, it has been the general desire to so proportion these compounds as to give fluidity and rapid fusion, without frothing. I have found that if compounds of boron are added in suitable quantity the resulting mixture will fuse readily without frothing, will be quite fluid so that homogeneity is attained, and will have a low coefficient of expansion. Furthermore the addition to the bond mixture of the boron increases the temperature range of fusing so that such nicety of control of the temperature within the oven during manufacture need not be maintained as with bond mixtures heretofore used, without boron.

As stated above bonds are usually made up of mixtures of natural clays, and the like, which contain a large number of various constituents; but these bonding materials may be, for purposes of convenience in description, grouped in three general classes,— namely, oxides of the alkali and alkaline earth metals designated generally "RO"; oxides of aluminum and the like designated generally "R_2O_3"; and a group called generally "acid" which comprise compounds such as SiO_2. The relative proportions of the various groups and of the several members of each group have been generally determined empirically and to make admixing easy the proportions have been set out in terms of numbers of molecules. That is to say the relative quantities desired having been determined they are stated in terms of relative numbers of molecules in each group, or what is for convenience termed "molecular ratios." Thus a fair mixture as heretofore used might be

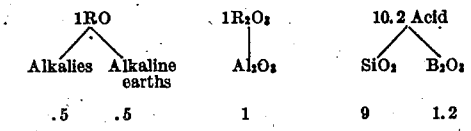
RO	R_2O_3	Acid
1	1	6

which means that there should be used the same number of R_2O_3 molecules as there are used RO molecules, but six times as many acid molecules as there are RO molecules. And RO includes all of the alkali and alkaline earths.

Of course the relative proportions of the alkali and alkaline earth compounds must also be determined. These again may be determined in the same way. For example the relative proportions may be 9 molecules of alkalies to 1 molecule of alkaline earths. This would give a bond which is readily fusible, but of high coefficient of expansion. The relative proportions of these two groups of compounds may be considerably varied with respect to each other; but the relation of the total RO group to the total of other groups should remain the same.

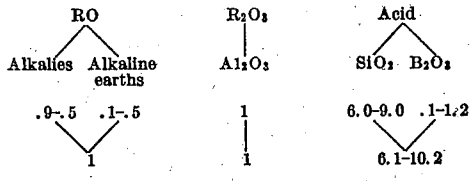
Now, as stated above, I have found that the addition of boron compounds, particularly boron oxide, or boracic acid, will increase the fusibility, the fluidity of the fusing mass, and will also lower the coefficient of expansion of the resultant fused binder.

So that by adding boron compounds the proportion of alkalies relative to alkaline earths in the RO group may be greatly decreased, and more satisfactory results attained. For example, I have found the following formula to constitute a very satisfactory bond:—



the proportions being in molecule ratios.

Of course, this precise proportion of the bond constituents is not essential; and may be rather widely departed from and satisfactory results secured. To illustrate, in terms of molecular ratios, the proportions may be varied over a considerable range, as follows:—



In actual practice very satisfactory results have been obtained where the percentage of boron compound varied from 3% to 10% of the whole quantity of bonding material, by weight. The most desirable proportion of boron compound will depend upon the relative proportions of other constituents—such for example as the proportion of alkalies to alkaline earths in the RO group—and as low as 1% of boron compounds by weight will have appreciable effects; while as high as 20% may be used satisfactorily. And the practicing of this invention gives results heretofore not attained, for, to my knowledge no one has heretofore provided a ceramic abrading wheel in which expansion during use is negligible; which has a substantially negligible coefficient of expansion; either of the wheel as a whole or of the bonding material; and which is therefore non-disruptive.

Such a bond is able to withstand temperature shocks to a degree hitherto unknown in connection with previously known abrading wheels, and as a result the wheel is much longer lived than previously known wheels. Furthermore such a bond has greater physical strength than other known bonds. I have made comparative breaking tests on wheels made with the old regular bonds and with the bond shown above, but using only half as much of the new bond as of the old, and have found such new bond wheels to show greater physical strength—to require a greater force to break them—than the old bond wheels. This is a matter of great practical importance for the abrading effect of the wheel is due to the particles of abrasive material, the bond merely acting as a holder for this abrasive material. And any increase in the quantity of abrasive material for a given working surface means greater effectiveness and also longer life.

Such new bond, when it has been fused and cooled, will have a "negligible" coefficient of expansion. And an abrasive wheel in which is used such bonding material will also have a "negligible" coefficient of expansion. By the term negligible as used here, I do not, necessarily, mean that the bond, or the wheel as a whole, has a zero coefficient of expansion; but that the coefficient of expansion is relatively so low that the danger of general or local rupture or disintegration of the wheel due to temperature shocks or unequal expansion during use is decreased to a point practically unobjectionable, or even substantially eliminated.

I have also found that, apparently, in its ordinary commercial state boric oxid, boracic acid, borax, or the like, may not be added to the bond to give satisfactory results. When so added to the bond the resulting wheel when it cools will often disintegrate with almost explosive violence. But this objectionable behavior will be avoided if the boron compound is first treated to permanently remove its water of crystallization or rendered insoluble. One satisfactory and simple method of rendering such compounds suitable for use is to fuse the boron compound with silica containing compound to form a complex silicate. A suitable proportion of such fused boron compound, properly ground, is admixed with a proportional quantity of bonding material in the ordinary form of plastic clay, the abrading material being also admixed therewith, after which the wheels are molded to the desired form and then fused to the finished condition.

While the abrading material or wheel herein described and the method of making it constitute preferred embodiments of the invention, it is to be understood that the invention is not limited thereto, and that changes may be made therein without departing from the scope of the invention which is defined in the appended claims.

What is claimed is:—

1. A ceramic abrasive wheel composed of material which includes an abrasive substance and a bond comprising compounds of the alkali metals and of the alkaline earth metals, and boric oxid, said bond constituents being present in proportions so controlled that upon fusion into a completed wheel said wheel will have a negligible expansion during use.

2. A ceramic abrasive wheel composed of material which includes an abrasive substance and a bond comprising compounds having the general formula RO, R_2O_3 admixed with compounds designated acid, the compounds being admixed in the general ratio of 1:1:9 when determined in molecular equivalents.

3. A ceramic abrasive wheel composed of material which includes an abrasive substance and a bond comprising compounds having the general formula RO, R_2O_3 admixed with compounds designated acid, the compounds being admixed in the general ratio of 1:1:9 when determined in molecular equivalents, the acid compounds comprising boron oxide in the proportion of from .1 to 1.2 in molecular equivalents, of the entire quantity of acid compounds.

4. A ceramic abrasive wheel composed of material which includes an abrasive substance and a bond comprising from .1–.5 of alkaline earth compounds and .1–1.2 of boron compounds, in terms of molecular equivalents, said bond when fused having a negligible expansion during use.

5. In the preparation of an abrasive wheel, in which an abrasive material is admixed with a bonding material, and given a predetermined shape after which the shaped wheel is heated in a kiln to fuse the bonding material; the method of preparing bonding material which comprises fusing a boron compound with silica compounds to form complex boron silicate and incorporating the resulting fused mass in the bonding material with the boron present in the bonding material in the proportion of from .1 to 1.2, in terms of molecular equivalents.

6. A ceramic abrasive wheel, which is composed of material which includes an abrasive substance, and a fused ceramic bond comprising a previously fused compound of boron, said bond when fused being of negligible expansibility during use.

7. A ceramic abrasive wheel, which is composed of a material which includes an abrasive substance, and a fused ceramic bond comprising previously fused boric oxid, said bond when fused being of negligible expansibility during use.

8. A ceramic abrasive wheel composed of materials which include an abrasive substance and a ceramic fused bond comprising a compound of boron, said compound being present in the proportion of from 3 to 10% of the total weight of the bond, said bond when fused having negligible expansion during use.

9. A ceramic abrasive wheel composed of an abrasive substance and a bond comprising silica, boron, sodium and aluminum fused together, the constituents of said bond being in proportion so controlled that in the resulting completed wheel the bond has a negligible coefficient expansion.

10. A ceramic abrasive wheel composed of an abrasive substance and a fused bond, said bond being composed of materials relatively so proportioned that the completed fused wheel will be free from objectionable disruptive forces, the materials of which said bond is composed comprising .5 of alkaline earths and 1.2 of boron oxid in terms of molecular equivalents.

11. In the preparation of abrasive wheels, in which an abrasive material is admixed with a bonding material comprising as one constituent a substantial proportion of a boron compound; the method which comprises treating the boron compound before its admixture with additional bonding material, to render it insoluble, and admixing such treated boron compound with a preponderance of additional bonding material, the said materials being relatively so proportioned that upon fusion of the bond the completed wheel will be free from objectionable disruptive forces due to expansion and the like.

12. In the preparation of an abrasive wheel, in which an abrasive material is admixed with a bonding material, and given a predetermined shape after which the shaped wheel is heated to fuse the bonding material; the method which comprises fusing a boron compound with silica compounds to form complex boron silicates, admixing the resulting fused material with a preponderating amount of additional bonding material, incorporating the resulting abrasive material within the admixed bonding materials, subjecting said admixed bonding material and abrasive material to fusion to form an abrasive wheel, the several constituents of said bonding material being so relatively proportioned that upon fusion the resulting completed wheel will have a negligible expansion during use.

13. The method in formation of ceramic abrasive wheels, which comprises admixing abrasive material with a bonding material comprising as constituents thereof oxides of silicon, alkali and alkaline earth metals, and boron with the relative proportions of such oxides so controlled that upon fusion the resulting fused bond during use will have a negligible expansion; forming such admixed abrasive material and bonding material into desired shape; and then fusing the shaped body.

14. The method in the formation of ceramic abrasive wheels, which comprises admixing clay containing oxides of silicon, aluminum, and sodium in controlled proportions, with a previously fused compound of boron, to give a resulting bonding mixture of controlled relative constituents, the proportions of the various named compounds being such that on fusing the bond will have a negligible expansion during use.

15. An abrasive wheel composed of an abrasive material and a fused bond, said bond comprising a fused mixture of a boron compound and clay containing an admixture of oxides of silica, and alkali and alkaline earth metals, the relative proportions of the constituents going to make up such said bond be-

ing such that upon fusion the resulting fused bond will have a negligible expansion during use.

16. For use as a constituent in the bonding material which goes to make up an artificially prepared abrasive wheel, and as a composition of matter, a complex boron silicate formed by fusing a boron compound with a silica containing compound, the constituent compounds being so proportioned as to give to the fused complex boron silicate a predetermined composition range adapted to impart to the fused mass a negligible coefficient of expansion.

In testimony whereof I hereto affix my signature.

HERBERT R. SIMONDS.