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ABRASIVE TOOLS AND METHODS OF MAKING SUCH TOOLS

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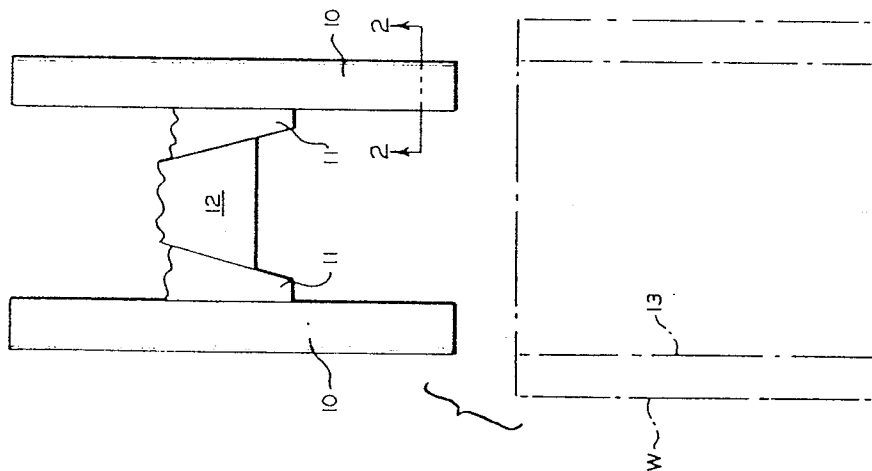


FIG. 1

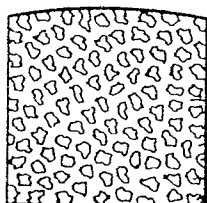


FIG. 2

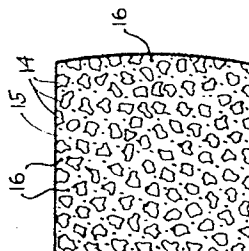


FIG. 3

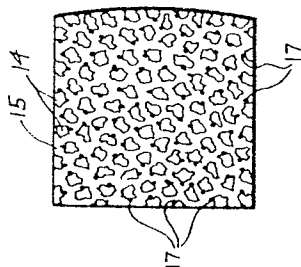


FIG. 4

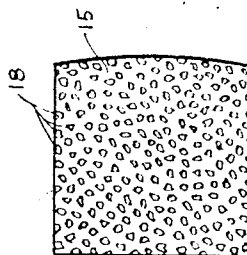


FIG. 5

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ABRASIVE TOOLS AND METHODS OF MAKING SUCH TOOLS

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18 Claims. (Cl. 51—298)

This application is a continuation-in-part of copending application Ser. No. 143,862, filed Oct. 9, 1961, and now abandoned, which in turn was a continuation-in-part of application Ser. No. 676,093, filed Aug. 5, 1957, and now U.S. Patent No. 3,003,860.

This invention relates to abrading tools such as honing stones and to methods of making tools of this type.

One of the prime objects of the invention is to provide an abrasive machining element of improved character having a uniformly wearing or disintegrating matrix carrying the abrasive grains which is particularly well suited to precision abrading operations such as honing.

Another object of the present invention is to provide a physically uniform abrasive body, having good thermal conductivity characteristics, which can be used to machine relatively thin sections without heating them to the range where distortion occurs.

Another object of the invention is to provide an abrasive body of the character described which is self-lubricating so that build-up of heat due to friction tends to be minimized.

A further object of the invention is to provide an abrasive body having a clean, uniform abrading action which is well suited to automatic machining operations.

A still further object of the invention is to provide a honing tool having a matrix which is capable of damping vibrations created during the honing operation and provides a steadier abrading action enabling greater accuracy to be obtained.

Another object of the invention is to provide an abrading element of improved character which can remove material from the workpiece much more efficiently than conventional abrasive bodies employing identical abrasive grains.

A further object of the invention is to provide an abrasive tool which can be strengthened by compounds formed by the reaction of additives with the bond or abrasive grain in a manner to permit the controlled variance of the rate of wear or progressive break-down of the matrix.

Another object of the invention is to develop a carbon bonded abrasive tool and a process of forming such a tool which is economical and practical in nature.

A further object of the invention is to provide a highly efficient and reliable abrading tool of strong and rugged construction which is capable of resisting high compressive forces, and which is well suited for machining ferrous and non-ferrous metals, and various non-metallic bodies.

A still further object of the invention is to provide an abrasive tool, having a clean cutting action capable of producing a bright, lustrous, high precision finish, which can be operated at increased abrading speeds, if desired.

These and other features of the invention, and the novel method referred to, will be more fully apparent from the following description and well be particularly pointed out in the appended claims.

In the drawing:

FIGURE 1 is a schematic elevational view illustrating an embodiment of the invention in which honing stones constructed in accordance with the invention are employed to machine a cylinder;

FIGURE 2 is an enlarged cross-sectional view of one of the stones taken on the line 2—2 of FIGURE 1;

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FIGURE 3 is a similar cross-sectional view illustrating the composition of a slightly modified stone;

FIGURE 4 is another cross-sectional view illustrating the composition of still another stone; and

FIGURE 5 is a similar cross-sectional view illustrating the composition of a stone wherein the abrasive grains are formed by chemical reaction.

Referring now more particularly to the drawings, wherein we have schematically shown the honing head of a conventional type honing machine, a numeral 10 generally indicates replaceable honing stones 10 which are shown supported by holder elements 11. In machines of this type an automatically controlled, axially movable member 12, having a coniform surface, continuously feeds the circumferentially disposed honing stones 10 into the bore 13 of a workpiece W at a slow and uniform rate. During the honing operation the head and the honing stones 10 which it carries) is continuously revolved and is simultaneously reciprocated in an axial direction in the usual manner, so that the stones 10 during this particular machining operation are in a state of compression. The instant invention is concerned with the composition of the abrading element or stone, and the methods of making and using the element. Accordingly the honing operation briefly described is set forth for purposes of illustration only and it is to be understood that other abrading or cutting actions might as easily have been depicted.

In the species of the invention disclosed in FIGURE 2 uniformly dispersed, abrasive grains 14 are shown bonded in a carbon-graphite matrix 15. When a stone of such composition is employed, the disintegration of the matrix is uniform and, as the matrix wears away, the dulled partially exposed abrasive grains are torn out by the friction developed and the underlying grains are exposed to continue the cutting action. It is highly desirable that the partially exposed abrasive grains drop out and be replaced prior to the time that their exposed cutting edges are dulled sufficiently so that they contribute little to the abrading action. Further, it is desirable in automatic abrading operations that the rate of disintegration of the matrix be uniform so that as the abrading operation proceeds approximately the same amount of material is removed from the workpiece per unit of time.

The carbon or carbonaceous matrix or bond provided is a solidified, carbon bonded, carbon-graphite mixture in which the abrasive grains are uniformly dispersed. By a carbon-graphite mixture is meant a mixture of graphite, which technically is elemental carbon, of course, and any other non-graphitic form of carbon. Particles of aluminum oxide, silicon carbide, diamond, titanium diboride, boron carbide, tungsten carbide, titanium carbide, molybdenum carbide, chromium carbide and other abrasive grains of relatively greater hardness than the matrix composition can be used to provide the abrading actions.

The carbon-graphite matrix illustrated in FIGURE 2, which is of a hard, baked character, is formed from a raw mixture of coal tar pitch and pulverulent, amorphous, natural graphite in a manner to be presently described. The mixture has been found to produce a satisfactory matrix if the mixture provides 20–70 parts by weight of pitch to 80–30 parts by weight of graphite. To provide a high strength matrix of good quality for honing or abrading the composition is preferably at least 30% pitch by weight and ideally will be 45–50% pitch by weight. If the pitch content is greater than 70% by weight the body formed may shrink and crack, and exhibit other undesirable characteristics. The pitch and graphite are placed in a steam jacketed, intensive mixer of the double sigma type and thoroughly blended while being heated relatively slowly to a temperature of approximately 165° C. As the composition is being heated, the constituents

of the composition are intimately blended by the mixer.

The pitch melts when a temperature of about 110° C is reached and thereafter certain liquid hydro-carbons are distilled from the pitch until such time as a solidified mass is removed from the mixer. In this solidified state the natural graphite and the pitch residue are thoroughly blended into a homogenous mass which has been phase reversed from a relatively liquid to solid state, however, the pitch residue still contains hydro-carbons which at higher temperatures than 165° C. will liquefy and "wet" the graphite. The mass is then finely pulverized and screened, after which the abrasive grains to be used are added in a manner to be described and the mixture is pressed into a honing stone or abrasive wheel, as the case may be.

While the size of the pulverized mix particles and abrasive grains is variable to suit particular abrading operations, a mixture consisting of abrasive grains up to 600 mesh blended with 100-200-mesh particles of the phase reversed mix provides a very satisfactory composition. The blend of mix and grain will be in the ratio of 10-90 parts by weight of mix to 90-10 parts by weight of abrasive grains. The blend should be at least 10 parts abrasive to obtain an abrading action from the tool to be formed. A composition which provides 40-60 parts by weight of abrasive grains to 40-60 parts by weight of phase reversed mix has been found to be very satisfactory for most purposes. From a practical standpoint if more than 60% abrasive grain by weight is used, honing results with the tools formed are not improved and with some abrasives the use of more than 60% results in less efficient honing of decreased quality. Accordingly, for most purposes the phase reversed pitch and graphite mix content should be at least 40%.

If the abrasive grains and phase reversed mix particles are simply blended and transported to the molding presses for forming the tools in large containers, it has been found that in instances where the grains are heavier than the mix particles and a time interval elapses before the contents of the containers are used, the grains tend to sink somewhat in the mix, and this affects the uniformity of the tools which are formed. Also, when the abrasive grains are somewhat lighter than the mix particles with which they are to be blended, the mix particles tend to settle relative to the grains and this also, of course, affects the uniformity of dispersion of the grains somewhat. To avoid this settling effect and provide a more uniform tool as an end product, the grains, prior to blending, are immersed in a suitable tacky, i.e., binder material, e.g., a sugar solution, and are then tumbled with the mix particles so that they become coated therewith. This has the effect of providing pellets, which include individual abrasive grains having adhering mix particles, which can be screened to a particular size, such as twenty mesh, for example. Then when the pellets formed are transferred in large containers to the presses, their weight is substantially the same and no settling occurs.

Suitable tacky, i.e., binder materials which can be used instead of a sugar solution include a dilute phenol formaldehyde solution, such as Durez No. 7347-A. Either the sugar or resin will, in subsequent processing of the tool, be burned to a free carbon state which is to be distinguished from a carbon incorporating some high order hydrocarbons and having a hard, crystalline character. So little carbon remains that it can be considered a negligible factor so far as the characteristics and performance of the tools are concerned. In general, the tacky or binder material must be one which is essentially inert with respect to the other ingredients in the tool and has a sufficient tackiness, e.g., greasiness or stickiness to at least temporarily bind the grains and mix particles and which is at least in part volatilizable, that is, either is evaporated or is decomposed to a free carbon state by baking at the temperatures used in forming the tool,

i.e., up to 2200° C. and usually about 475° C. to 2200° C. The material should evaporate without leaving substantial residue, generally less than 1 and preferably less than 0.1 weight percent of the finished tool. Similarly, if the material bakes to a free carbon state, generally the carbon produced should not exceed about 5, preferably 1 weight percent, of the finished tool. In the evaporation category, preferred materials are kerosene and fuel oil. However, generally speaking these latter two agents are more useful when an additive is incorporated in the tool, as will later appear.

In addition to the preferred tacky or binder materials described above, suitable materials include solutions of sugars including generally mono- and polysaccharides, liquid natural and synthetic resins such as rosin and shellac, fatty materials such as fats, glycerides and fatty oils including vegetable oils and soybean oil, and other liquid petroleum derived materials such as distillates boiling above the kerosene range, generally above 450° F., including range oil, diesel fuel, motor oil, machine oil and greases as well as fuel oil.

The pellets formed of the grains and mix particles are placed in a die cavity in a conventional molding press and molded under a pressure of 10 to 30 tons per square inch into an abrasive tool. In the instant case the honing stones shown are formed but other abrasive tools, such as grinding wheels, may, of course, be formed in a similar manner.

When the stones or tools are removed from the press, they are baked slowly in an oven which has an inert atmosphere at a relatively high temperature. During this baking operation the pitch is, of course, heated at least to its carbonization range and in the process of being reduced to free carbon thoroughly bonds the constituents including the abrasive grains. The baking process is slow and may continue for 12 hours or more as the tools are slowly brought to the desired temperature, which is usually in the range of 475°-2200° C. Such temperatures will provide a good carbonization of the pitch without causing deterioration of the abrasive grains. Preferably the range used is 1150° to 1350° C. to insure a thorough carbonization of the pitch and provide a strong free carbon bond. When aluminum oxide grains are used the temperature should not go appreciably above 1400° C.

The tool or stone when completed is of a hard, rigid character and in a broad sense the matrix serves as a bond for the relatively harder abrasive grains which are uniformly dispersed throughout the matrix. The graphite, which is a filler, and the free carbon reduced from the pitch, which in a more specific sense serves as the bond for both the graphite or other filler and grains, are both in an amorphous state. Graphite makes an excellent filler or vehicle because it is chemically inert at the temperatures mentioned and will not react chemically with the abrasive grains, and because the graphite is highly thermally conductive and the heat generated in the abrading action is rapidly dissipated. In fact a tool of the character described is up to ten to fifteen times more thermally conductive than the vitreous and resinoid tools in present use. For this reason the exposed grains do not fuse with the metal dust removed and tend to be dulled accordingly because the heat is rapidly conducted away from the abrading surfaces. This latter factor is important from the standpoint of achieving uniformity of disintegration of the stone in service although it is believed that other characteristics of the matrix described contribute to the result also. When other materials such as petroleum coke or silica, or other natural or synthetic graphites, are used as the filler in place of the graphite, improved tools are obtained from the standpoint of comparison with conventional tools because of the more uniform disintegration of a matrix bonded with free carbon; however, the graphite filler is preferred. Amorphous graphite is preferred to crystalline graphite. Additional materials which make suitable

fillers are zircon, zirconia, titanium and various mixes of these materials, including graphite, petroleum coke, or silica. If silica is used as the filler, the carbonization of the pitch carbon should be accomplished in the minimum carbonization range at about 475°–1100° C. In general, the filler should have a high thermal conductivity and be chemically inert at the temperature to which the tool is baked.

The coal tar pitch described above is believed to be the most satisfactory raw agent for providing the binder carbon. However, other compounds containing carbon in a combined state which have the property of wetting the graphite or filler at suitable temperatures such as referred to previously, i.e., 475° to 2200° C., and which can be carbonized to free carbon without leaving any appreciable impurities generally less than 1%, preferably less than 0.1%, by weight of the finished tool at such suitable temperatures can be used in amounts such as described above for the pitch. Such carbon compounds include anthracene, tars, pitches, chlorinated paraffins, and other hydrocarbon type compounds and other carbon compounds meeting these conditions will be satisfactory.

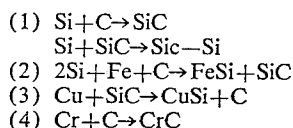
An abrasive tool formed in the manner described may in structure be as much as 20% voids and it may be desirable to provide a more dense tool. This can be accomplished through use of carbon fines in the form of lampblack, for example, in the initial mix. A highly satisfactory initial mix may, for instance, consist of 30–50% coal tar pitch by weight, 40–60% amorphous natural graphite by weight, and 10–15% lampblack by weight. Further, after being removed from the baking oven the tool is impregnated with a dilute phenol formaldehyde resin in a liquid state or other resin in any suitable manner such as by forcing the resin into the tool under pressure. Thereafter, the resin in the impregnated tool may be relatively slowly cured in situ at temperatures up to 180° C. This procedure introduces the resin to the voids in the amount of up to 12% by weight, which is not sufficient to materially affect the uniformity of disintegration or wear of the matrix or its high thermal conductivity.

The efficiency or performance of a honing stone formed in the manner described may be measured by comparing what may be termed its "volumetric ratio of removal" for a given diameter of bore with that of conventional stones. By the "volumetric ratio of removal" is meant the amount or volume of workpiece material removed or abraded away as compared with the amount or volume of material worn from the tool. Ideally this ratio should be constant during the service life of the tool if the same machining operations are being performed. However, commercial honing stones do not provide constant "ratios" at all. Any one tool may have a "ratio" varying from 10–1 to 25–1 at various times and the average might be about 17 cubic inches of material removed for every cubic inch of stone removed.

Stones made in accordance with the disclosure of the present invention are characterized by a uniform "ratio of removal" and further with the addition of certain chemically reactive additives to the mixture, prior to the forming of the tool in the press, can be provided with the particular "volumetric ratio of removal" desired. In the machining of various workpieces tools having particular "ratios of removal" will perform the abrading operation better than others and provide the surface finish and precision desired. Thus, if a stone can be provided which has a relatively uniform "ratio of removal" it can be specified with some degree of confidence for a particular operation. The value of being able to consistently produce stones which in service will have the "ratio of removal" desired without testing each one will also be apparent.

A very important aspect of the instant invention lies in being able to control the "ratio" a particular stone will have without varying the basic constituents of the stone or the method of making it, and in being able to produce

stones which will have various uniform "ratios of removal" as desired. This control is effected by adding certain materials to the mix at the time the abrasive grains are blended which will chemically react with the carbon in the matrix or with the abrasive grains. If the additive reacts with the carbon in the matrix, compounds of molecular size such as at 16 (FIGURE 3) are formed which are dispersed uniformly throughout the carbon-graphite matrix. However, if the additive reacts with the grain, compounds of molecular size 17 (FIGURE 4) are formed on the surface of the abrasive grains. These compounds strengthen the bond without materially affecting the uniformity of disintegration or wear of the tool but do materially affect the volumetric "ratio of removal" of the tool in service. When the reaction is with the free bonding carbon in the matrix the bond itself is strengthened and when the reaction occurs at the surfaces of the abrasive grains a better gripping surface on the smooth grains is believed provided for the bond material which strengthens the link between the bond and grains. By adding controlled amounts of certain additives tools can be formed which will have the desired volumetric "ratio of removal." When the additive reacts with the carbon in the matrix, carbides are formed as the molecular compounds, whereas when the reaction takes place with abrasive grains such as silicon carbide other compounds such as silicides may be formed. These solid state reactions which take place when the reacting elements are in a solid phase occur during the baking cycle when the stones with the additives intimately blended with the other constituents and uniformly dispersed throughout the matrix are brought up slowly to relatively high temperatures. When metals, or metal compounds, such as (1) silicon, (2) silicon containing 0.1–10% iron, (3) copper, and (4) chromium are added to the carbon-graphite mix described at the same time silicon carbide abrasive grains are added, with the additive in the proportion of 0.1% by weight of the mix to 25% by weight of the mix, the following solid state reactions are believed to occur to obtain the following water insoluble carbides or silicides in a very fine molecular state:



The above reactions are intended to be illustrative of additives which may be employed with tools of the novel character described in which silicon carbide is used as the abrasive. In the first example there is a solid state reaction between the bonding carbon and the silicon at the high temperature mentioned. Also, the presence of silicon at the grains will create an interphase condition in which silicon carbide of the grain is in solid phase solution in an excess of silicon at the grain at the high temperatures mentioned. When the temperatures are decreased, it solidifies in this interphase state to provide a better link between the bond and the grain. Silicon carbide stones such as described are well suited to the abrading of cast iron and in practice have been able to hone more than twice as many cylinders as conventional stones of the same size. If the additive employed is chromium, titanium hydride, or zirconium hydride, the reaction is with the bonding carbon in the matrix as is the case in Examples 1, 2 and 4 and carbides are formed. The additives should be an element or a compound containing an element which will react with carbon to provide a water insoluble carbide or react with silicon, boron or other such elements in the abrasive grain to provide a water insoluble silicide, boride, nitride, or the like to permit control of the volumetric "ratio of removal" and the strength and rate of wear of the bond. The volume of additive used is preferably kept under 25%, since otherwise the abrasive grains are not properly released

by the matrix when they become dulled and the abrading action is poor. It is possible, for instance, to provide a honing stone which has a "volumetric ratio of removal" of 140-1 following the method described if near maximum amounts of additives are used. While we have mentioned *metallic additives*, it will be possible to use non-metallic inorganics which would chemically react with the matrix or the grain to provide stable compounds.

When aluminum oxide abrasive grains are employed for machining surfaces such as steel, similar additives including silicon are used. This results in the formation of aluminum silicide at the surfaces of the grains as well as silicon carbide in the bond.

In a preferred embodiment of the invention, silicon in the mesh range 100 to 200 is employed as an additive in an amount of about 5 parts by weight to 95 parts by weight of the phase reversed mix-abrasive grain composition. In order to intimately blend the abrasive grain, silicon, and phase reversed pitch-graphite mix particles in a manner to provide composite particles of substantially equal weight, the grains are preferably first tumbled in a container having the requisite amount of silicon to coat the grain with silicon. It has been determined that the silicon has a definite molecular attraction for silicon carbide grain and will adhere thereto. It will also adhere in the same manner to aluminum oxide grain and other grains tumbled with it. In some instances, dependent on the particular abrasive grain being used, it will be desirable to wet the grain with kerosene or fuel oil prior to tumbling the grain in the silicon. In the latter case if the silicon coated grains are left overnight at room temperature, the kerosene or fuel oil will have substantially evaporated and the silicon coated grains can then be coated with the sugar solution or the resin solution previously mentioned. Thence, the sugar coated particles can be tumbled with the requisite quantity of phase reversed pitch-graphite mix to provide composite particles for the mold. The penetration of the solution will be sufficient to wet the silicon through to the surface of the abrasive grains so that there is a sugar solution bond between the abrasive grain and silicon particles and between the silicon particles and phase reversed pitch-graphite mix particles. This method is preferred over a second method wherein the bare abrasive grains are wetted with sugar solution and tumbled with a composite particulate mixture comprising particles of silicon and phase reversed pitch-graphite particles intimately blended in proper proportions. It is also preferred that all of the silicon to be added be tumbled with the grains and all of the phase reversed pitch-graphite particles to be used in a particular proportion be tumbled so that no residue of either remains to be later intimately blended prior to forming the tools in the press. Tools could be formed according to the latter methods, of course, but certain difficulties arise.

As examples of the described product and method the following will yield satisfactory results and the proportions mentioned are by weight unless otherwise indicated.

Example 1

A carbon-graphite mix containing 45 parts of coal tar pitch and 55 parts of amorphous natural graphite is phase reversed at 165° C., cooled, and finely pulverized to 200 mesh. 100-mesh silicon carbide abrasive grains in a quantity which will provide a ratio of 50 parts mix to 50 parts abrasive grain are then immersed in a cane or beet household sugar solution comprising 60 cc.'s of solution per pound of abrasive grain. The sugar solution is of the type of 200 grams of sugar per 1000 cc.'s of water. Various degrees of tackiness are useful and the solution could be somewhat more or less dilute, dependent on the proportions of ingredients to be mixed. Once the grains are thoroughly wetted they are then tumbled in the requisite quantity of 200-mesh phase reversed pitch-graphite mix, the tumbling producing mix coated grain pellets consisting substantially of 50 parts

mix to 50 parts grain. The pellets are then screened to 20 mesh and delivered to a press which presses them into a honing stone $\frac{3}{8}$ " by $\frac{3}{8}$ " by 3" in a press using a pressure of 15 tons per square inch at the die cavity. This article is baked slowly in a furnace with an inert atmosphere at a temperature gradually increased to 1200° C. over a period of 14 hours. The tool formed was found to be highly satisfactory for honing cylinders in cast iron blocks.

Example 2

The composition and method employed in Example 1 except that alumina grains were used in place of the silicon carbide grains and the tool was found to be very satisfactory for honing steel tubing.

Example 3

The composition and method employed in Example 1 except that a phenol formaldehyde resin solution, Durez No. 7347-A, consisting by weight of 70% hydrocarbon and 30% water, is diluted with an additional 25% water relative to the weight of the solution and substituted for the sugar solution used. It has been determined that this method is satisfactory to produce abrasive tools for some purposes. However, it has been noted that the electrical resistance of a tool produced in this manner is increased and thus the sugar solution is preferable.

Example 4

The composition and method employed in Example 1 except that aluminum oxide grains are used and prior to being immersed in the sugar solution the grains are immersed in kerosene and, when thoroughly wetted, are withdrawn and tumbled in a quantity of 200-mesh silicon particles in the amount of $2\frac{1}{2}$ pounds of silicon to 50 pounds of grain. The silicon coated grain is then permitted to stand for approximately twelve hours at room temperature to permit the kerosene to evaporate. Thence, the silicon coated grain is immersed in sugar solution, as described in Example 1.

Example 5

The composition and method employed in Example 1 except that the grains are tumbled in 100-mesh silicon particles prior to being tumbled in the phase reversed pitch-graphite mix particles.

Example 6

The method employed in Example 4 except that phenol formaldehyde solution, as in Example 3, is used in place of the sugar solution.

Example 7

The composition and method employed in Example 1 except that anthracene is used in place of the coal tar pitch.

Example 8

The composition and method employed in Example 4 except that 200-mesh copper particles in the amount of 20 parts to 80 parts of the phase reversed mix-abrasive grain is used instead of silicon.

Example 9

The composition and method employed in Example 1 except that Hercules Powder Co. Clorafin 40 was used in place of the coal tar pitch in the amount of 60% clorafin to 40% graphite.

Example 10

The method of Example 4 except that the sugar solution of Example 1 diluted 100 percent is used in place of the kerosene.

Example 11

Satisfactory honing tools are produced by the methods of Examples 1 and 4 substituting for the alumina grains,

respectively, diamond grains, titanium diboride grains and chromium chloride grains.

Example 12

Satisfactory abrasive tools are produced by the methods employed in Examples 1 and 4 substituting for graphite, respectively, silica and petroleum coke.

Example 13

Satisfactory abrasive tools are produced by the methods employed in Examples 1 and 4, substituting for the sugar solution, respectively, fuel oil, kerosene, soybean oil and motor oil.

Example 14

Satisfactory tools are produced by the method employed in Example 4, substituting for the silicon, respectively, chromium, silicon containing 0.1 to 10% iron and titanium hydride.

The coal tar pitch preferred and used is a high melting range pitch obtained from the Barrett Division of Allied Chemical and Dye Corporation which has a high coking value. This pitch has a free carbon content of 27-32%, a coking value of 40%, and an ash content of less than 1%. It melts at temperatures between 206-218° F. and is broken down to particles less than 1/4" in size before being mixed with the graphite. The graphite preferred and used is the Mexican type designated No. 205 by the supplier, United States Graphite Division of the Wickes Corporation, which is about 95% carbon and is guaranteed to contain less than 15% ash. It is used in particles sizes of 100-mesh or finer and preferably its particles will be 200-mesh in the form in which it is mixed with the coal tar pitch.

The high strength of the stones formed is due in part to the phase reversing step described wherein the more volatile hydrocarbons are removed from the pitch at a temperature of 165° C. in the double sigma type mixer. The resulting solidified composition when removed from the mixer is denser and less porous than if these hydrocarbons were not removed. Also, the extreme pressures used in compacting the stones, which are measurable in tons per square inch, provide stones of higher strength. The high strength which is necessary to abrasive stones is maintained at optimum levels also by the use of proper fillers. Amorphous graphite is much preferred to crystalline graphite which, when used in the place of the amorphous natural graphite, does not provide a stone suitable for most abrading operations. The material used as the filler must have certain other characteristics in addition to providing a high strength stone, of course. It must be chemically inert at the temperature at which the tool is baked and must be highly thermally conductive. In addition to graphite, petroleum coke, and silica, zircon, zirconia, titanium, and various mixes of these materials have these latter properties and may be used as the filler material but are not as suitable as amorphous natural graphite.

The strength of the stone may be varied by varying the amount of time the stone remains in the oven. The stones may be removed, for instance, before carbonization is entirely complete. Generally the stones are brought slowly up to temperature for 12 hours, remain at temperature for two hours or so, and then are brought slowly down in temperature again for several hours prior to removal.

When an artificial resin such as phenol formaldehyde is forced into the remaining voids in the stone after the stone is removed from the oven the strength of the stone is also affected. Filling of the voids in this manner, through use of a resin which can be thinned and forced in, of course, tends to increase the strength of the stone. The compound used may be Monsanto #410 water soluble phenolic resin, an epoxy resin, shellac, or something equally suitable.

The above examples are included herein to illustrate

various forms of the invention, however, it is to be understood that equivalents may be used within the spirit of the invention and the specification is in all cases to be interpreted as illustrative of the invention rather than as limiting the same in any way.

It is claimed:

1. A method of preparing an abrasive tool having a uniformly wearing, strongly bonded carbon matrix and about 10 to 90 weight percent abrasive grains which are also uniformly dispersed in the matrix and are of greater hardness than the matrix comprising: tumbling the grains with particulate silicon to adhere the silicon to the grains by molecular attraction; applying to the grains a sugar solution which can be devolatilized by baking to a state in which it does not affect the performance of the tool; coating the grains with solid particulate hydrocarbon derived from pitch by distillation therefrom of liquid hydrocarbons at a temperature of about 165° C. to form composite particles having the grains coated with solid hydrocarbon; compressing the mix into a rigid body; and slowly baking the body in an inert atmosphere at a temperature to dehydrogenize the hydrocarbon and devolatilize the sugar solution to form a carbon matrix and bond the grains in the matrix.

2. A method of preparing an abrasive tool having a uniformly wearing, strongly bonded carbon matrix and about 10 to 90 weight percent abrasive grains which are also uniformly dispersed in the matrix and are of greater hardness than the matrix comprising: tumbling the grains with particulate silicon to adhere the silicon to the grains by molecular attraction; applying to the grains a phenol-formaldehyde resin solution which can be devolatilized by baking to a state in which it does not affect the performance of the tool; coating the grains with solid particulate hydrocarbon derived from pitch by distillation therefrom of liquid hydrocarbons at a temperature of about 165° C. to form composite particles having the grains coated with solid hydrocarbon; compressing the mix into a rigid body; and slowly baking the body in an inert atmosphere at a temperature to dehydrogenize the hydrocarbon and devolatilize the resin solution to form a carbon matrix and bond the grains in the matrix.

3. A method of preparing an abrasive tool having a uniformly wearing, strongly bonded carbon matrix and about 10 to 90 weight percent abrasive grains which are also uniformly dispersed in the matrix and are of greater hardness than the matrix comprising: applying to the grains a binder material essentially inert with respect to the grains and which is at least in part volatilizable at a temperature below about 2200° C. to a state in which it does not affect the performance of the tool; coating the grains with solid particulate hydrocarbon which can be carbonized to free carbon to form a mix of composite particles comprising the grains having the solid hydrocarbon adhered thereto by the binder material; compressing the mix into a rigid body; and slowly baking the body in an inert atmosphere at a temperature sufficient to carbonize the hydrocarbon and volatilize the binder material to form a carbon matrix and bond the grains in the matrix.

4. The method of claim 3 wherein the solid particulate hydrocarbon is added as a blend consisting essentially of about 20 to 70 parts solid hydrocarbon and about 80 to 30 parts of substantially inert filler, said hydrocarbon wetting the filler during said baking to form a strongly bonded matrix.

5. The method of claim 4 wherein the filler is graphite.

6. The method of claim 5 wherein the hydrocarbon is a solid hydrocarbon derived from pitch by distillation therefrom of liquid hydrocarbons at a temperature of about 165° C.

7. A method of preparing an abrasive tool having a uniformly wearing, strongly bonded carbon matrix and about 10 to 90 weight percent abrasive grains which are also uniformly dispersed in the matrix and are of greater

hardness than the matrix comprising: applying to the grains a binder material essentially inert with respect to the grains and which is at least in part volatilizable at a temperature below about 2200° C. to a state in which it does not affect the performance of the tool; coating the grains with solid particulate hydrocarbon derived from pitch by distillation therefrom of liquid hydrocarbon at a temperature of about 165° C. to form composite particles comprising the grains having the solid hydrocarbon adhered thereto by the binder material; compressing the mix into a rigid body; and slowly baking the body in an inert atmosphere at a temperature sufficient to carbonize the hydrocarbon and volatilize the binder material to form a carbon matrix and bond the grains in the matrix.

8. A method of preparing an abrasive tool comprising a uniformly wearing, strongly bonded carbon matrix and about 10 to 90 weight percent abrasive grains which are uniformly dispersed in the matrix and are of greater hardness than the matrix comprising: tumbling the abrasive grains with particulate silicon to adhere the silicon to the grains by molecular attraction; applying to the abrasive grains a binder material essentially inert with respect to the grains and which is at least in part volatilizable at a temperature below about 2200° C. to a state in which it does not affect the performance of the tool; coating the grains with solid particulate hydrocarbon which can be carbonized to free carbon to form a mix of composite particles comprising the grains having the solid hydrocarbon adhered thereto by the binder material; compressing the mix into a rigid body; and slowly baking the body in an inert atmosphere at a temperature sufficient to carbonize the hydrocarbon and volatilize the binder material to form a carbon matrix and bond the grains in the matrix.

9. The method of claim 8 wherein the solid particulate hydrocarbon is added as a blend consisting essentially of about 20 to 70 parts solid hydrocarbon and about 80 to 30 parts of substantially inert filler, said hydrocarbon wetting the filler during said baking to form a strongly bonded matrix.

10. A method of preparing an abrasive tool having a uniformly wearing, strongly bonded carbon matrix, a metallic additive dispersed therein, and about 10 to 90 weight percent abrasive grains which are also uniformly dispersed in the matrix and are of greater hardness than the matrix comprising: applying a metallic additive to the grains; applying to the grains a binder material essentially inert with respect to the grains and which is at least in part volatilizable at a temperature below about 2200° C. to a state in which it does not affect the performance of the tool; coating the grains with solid particulate hydrocarbon which can be carbonized to free carbon to form

a mix of composite particles comprising the grains having the solid hydrocarbon adhered thereto by said binder material; compressing the mix into a rigid body; and slowly baking the body in an inert atmosphere at a temperature sufficient to carbonize the hydrocarbon and volatilize the binder material to form a carbon matrix and bond the grains in the matrix.

11. The method of claim 10 wherein the metallic additive is added in the proportion of about 0.1% to about 25% by weight of the mix and the additive chemically reacts with the carbon of the matrix to form a metal carbide.

12. The method of claim 10 wherein the metallic additive is added in the proportion of about 0.1% to about 25% by weight of the mix and the additive chemically reacts with the abrasive grains.

13. The method of claim 10 wherein the solid particulate hydrocarbon is added as a blend consisting essentially of about 20 to 70 parts solid hydrocarbon and about 80 to 30 parts of substantially inert filler, said hydrocarbon wetting the filler during said baking to form a strongly bonded matrix.

14. The method of claim 13 wherein the filler is graphite and the solid hydrocarbon is derived from pitch by distillation therefrom of liquid hydrocarbon at a temperature of about 165° C.

15. The method of claim 3 wherein said binder material essentially completely volatilizes.

16. The method of claim 3 wherein the residue remaining after volatilization of said binder material is less than 1 weight percent of the tool.

17. The method of claim 3 wherein said binder material decomposes upon volatilization to a free carbon state.

18. The method of claim 3 wherein the carbon produced upon decomposition of said binder material after decomposition thereof is less than 5 weight percent of the tool.

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