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METHODS OF MAKING ELECTROLYTIC TOOLS

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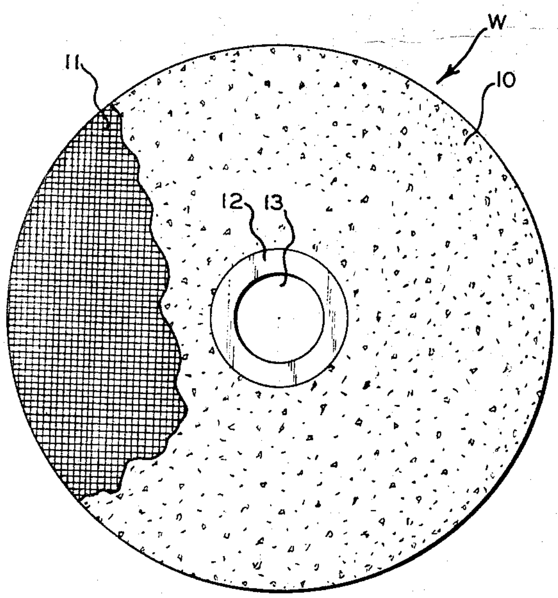

FIG. 1

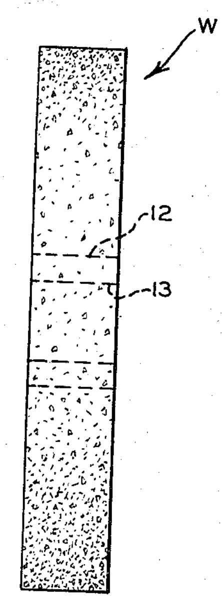

FIG. 2

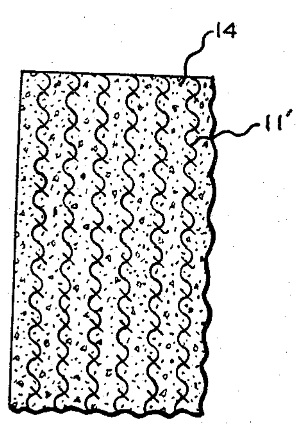

FIG. 3

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This invention relates to electrolytic tools and methods of preparing such tools, and more particularly to grinding wheels or belts having improved electrical properties for electrolytic grinding.

One of the prime objects of the invention is to provide a tool of the character described which provides the flexibility of laminated wheels or belts without sacrificing essential electrical conductance characteristics. In fact, the present invention is concerned with increasing the electrical conductance properties of the tool while at the same time increasing the tool's flexibility and operating life.

Briefly, the invention is concerned with the provision of spaced apart carbon or graphite laminae in an electrolytic grinding wheel or like tool which provide continuous electrical conductance paths from substantially the internal diameter of the wheel, for instance, to the grinding face thereof. Particularly where the tool comprises graphite and abrasive particles linked by a free carbon bond provided by the dehydrogenation of coal tar pitch, the desirable electrical characteristics thereof are considerably enhanced by the provision of such continuous paths within a wheel or the like which itself is highly electrically conductive.

A further object of the invention is to provide an abrasive tool of the general character described which can be readily and economically formed by the process to be described and which in operation is highly reliable and efficient.

A grinding wheel formed in the manner indicated is believed to be well suited to electrolytic form grinding and to what we term stage grinding wherein an abrasive wheel is used in an electrolytic grinding operation and then the power is turned off to permit the same wheel to conventionally grind a fine finish on the product. It is believed that the structure to be described is also well suited to electrolytic grinding belts of the endless or reciprocatory type and that even some resin bonded grinding wheels incorporating the carbon or graphite laminae may find use in some electrolytic machining operations.

Other objects and advantages of the invention will be pointed out specifically or will become apparent from the following description when it is considered in conjunction with the appended claims and the accompanying drawings, in which:

FIGURE 1 is a side elevational view of a typical grinding wheel formed in accordance with the invention, a portion of the wheel being broken away to illustrate the laminated construction thereof;

FIGURE 2 is an end elevational view thereof; and

FIGURE 3 is a greatly enlarged, fragmentary view of a modified form of wheel.

Referring now more particularly to the accompanying drawings and, in the first instance, to FIGURES 1 and 2, a letter W generally indicates a grinding wheel which is made up of an abrasive grain carrying, electrically conductive, carbonaceous body of a character to be described, with spaced apart, flexible, carbonaceous fabric discs **11** bonded therein. Electrically conductive hub means **12** having a bearing receiving opening **13** therein may be electrically connected with a source of power in the usual manner. For instance, electrically conductive brush means (not shown) connected with a suitable source of

electrical power may be in contact with the radial surface of the hub means **12** which may be formed of graphite, copper or a like highly electrically conductive material. Alternatively, the power may be applied to the shaft with which the wheel W rotates.

The carbonaceous disc body **10** is a rigid carbon-graphite mixture in which the abrasive grains are uniformly dispersed. By a carbon-graphite mixture is meant a mixture of graphite carbon, which technically is elemental carbon, of course, and another non-graphitic form of carbon which, in the present instance, forms a free carbon matrix in a manner to be presently described. Particles of aluminum oxide, silicon carbide, diamond, titanium diboride, boron carbide, tungsten carbide, titanium carbide, molybdenum carbide, and other abrasive grains of relatively greater hardness than the disc body **10** may be employed in the wheel. The carbon-graphite body **10** shown in FIGURE 1, which is of a hard-baked character, is formed from a raw mixture of particulate coal tar pitch and pulverulent amorphous natural graphite in a manner to be described. The mixture has been found to produce a satisfactory matrix for practical purposes if the raw mixture consists of 20 to 70 parts by weight of pitch to 80 to 30 parts by weight of graphite. To provide a high strength body of good quality, 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.

In the preparation of the tool, coal tar pitch and pulverulent 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 being intimately blended by the mixer and certain liquid hydrocarbons are being distilled from the pitch (which melts at a temperature of about 110° C.) until such time as a solidified mass can be removed from the mixer. In this solidified state, when the pitch has been partially dehydrogenized, the natural graphite and the pitch residue are thoroughly blended into a homogeneous carbonaceous mass which is then pulverized and screened.

While the size of the pulverized mix particles and the abrasive grains which are then mixed with them is variable to suit particular abrading operations, a mixture consisting of abrasive grains greater than 600 mesh in size blended with 100–200 mesh particles of the solidified carbonaceous mass provides a very satisfactory composition. The blend of mix and abrasive grains will be in the ratio of 10 to 90 parts by weight of mix to 90 to 10 parts by weight of abrasive grains. The blend should be at least 10 parts abrasive by weight to obtain an abrading action from the tool to be formed, but a composition which provides 40 to 60 parts by weight of abrasive grains to 60 to 40 parts by weight of carbonaceous mix or mass has been found to be very satisfactory for most purposes.

The abrasive grains chosen and the carbonaceous mass or mix particles, when intimately blended, are ready for a wheel-shaped die cavity in a conventional molding press and the blend or mixture formed is added in layers which are separated by flexible carbonaceous discs **11**. The discs **11** are preferably graphite fabric discs of the type prepared by carbonizing and graphitizing woven rayon cloth, for example, in an oxygen free atmosphere. Good results are obtained from plain woven rayon and other cellulosic fiber cloths such as cotton which are slowly heated in an inert atmosphere to a graphitization temperature.

A preferred graphite cloth which assays over 99° carbon may be prepared by heating a plain woven, rayon cloth to 5000° F. and will consist entirely of flexible graphite filaments. The graphite cloth employed should be flexible, and this flexibility will be due in large part to the small size of the filaments in the yarns used, which are preferably about 8 microns in diameter. The graphite cloth used is also very strong, having a tensile strength of 50,000 to 100,000 p.s.i., which is about 100 times standard forms of graphite, and has a very low elongation factor which is less than 1% at break. The cloth employed is sufficiently porous to permit penetration by the particles of mix so that the carbon matrix when formed will link through the perforations or spaces in the fabric. Typical fabrics will provide 24 yarns/inch in the warp and fill with a filament diameter of .0003 inch.

In filling the mold cavity, a layer of carbon-graphite mix and abrasive grain blend is first placed in the bottom of the mold around the hub **12** and a graphite cloth disc ring **11** is then laid on top. Then another layer of carbon-graphite mix and abrasive grain blend is placed on top, and so on. The graphite cloth discs **11** are disposed in the mold .005"–.125" apart and are about .005 of an inch in thickness, according to the particular electrolytic grinding operation to be performed. Preferably, the gap between discs **11** to provide desired electrical characteristics is .005"–.010".

Once the wheel, with its graphite cloth laminae, is compressed into a rigid body in the press at a pressure of 10 to 30 tons per square inch, it is removed from the press and baked slowly in an oven which has an inert atmosphere at a relatively high temperature in the range 475° to 2200° C. For best results, baking is usually accomplished in the range 1150° to 1350° C. and the temperature is raised relatively slowly to a temperature in this range and then lowered relatively slowly. During the baking operation, the pitch is heated to its carbonization range and, in the process of being reduced to a free carbon matrix, thoroughly bonds the constituents, including the abrasive grains. In the final product, free carbon links extend through the mesh openings in the graphite cloth and a thorough integration of the cloth with the carbon matrix is achieved. The actual baking process is slow and may continue for 12 hours or more as the tools are slowly brought up to the desired temperature and then slowly lowered to room temperature. The wheel, when completed, is of a hard, rigid nature and, in a broad sense, the free carbon matrix formed serves as a bond for the relatively harder abrasive grains and the graphite fabric discs **11**. As noted, the abrasive grains are uniformly dispersed throughout the wheel body **10** and the graphite discs **11** extend substantially from the hub means **12** to the periphery of the wheel but are, in practice, spaced a slight distance in the neighborhood of about .010 inch from both. Because the discs **11** are flexible and somewhat resilient, the uneven pressures of grinding do not tend to break them up. By uniform dispersement of the abrasive grains is meant a substantially even arrangement of the grains in the wheel body **10**, whatever their size. Graphite makes an excellent filler and an excellent conductive disc **11** because it is chemically inert at the temperatures mentioned and will not react chemically with the abrasive grains. Further, because graphite is highly thermally conductive, heat generated in the abrading action is rapidly dissipated.

It is possible that other inert pulverulent materials (at the temperatures involved), such as petroleum coke or silica, may be used as a filler in place of the pulverulent graphite, and in the case of silica dehydrogenation of the pitch should be accomplished at temperatures below 1100° C. While coal tar pitch is believed to be the most satisfactory raw agent for providing the binder carbon in the finished wheel, other compounds containing carbon in a combined state which have the property of wetting the graphite or filler at suitable temperatures and which can be carbonized to free carbon without leaving any appreciable impurities may be employed. Various tars, pitches, chlorinated paraffins, and other hydrocarbon type compounds meeting these conditions will be satisfactory.

To control the wear characteristics of the tool, pulverulent metal additives are usually added to the blend at the same time the abrasive grains are added. Good results are obtained, for instance, when additives such as copper and silicon are employed in the ratio of about 5 parts of the additive by weight to about 95 parts by weight of the carbonaceous mix-abrasive grain blend.

It may be desirable to form the abrasive grains by chemical reaction so that it is unnecessary to mix in abrasive grains. For instance, if sufficient silicon metal is added to the mixture, prior to the molding operation, it will react with the elements in the wheel body during the baking of the molded elements or tool at an elevated temperature and the hard compounds formed can function in place of the abrasive grains. In the case of silicon the reaction will provide silicon carbide particles dispersed uniformly throughout the relatively softer wheel body or, if titanium hydride and boron carbide are added in sufficient quantity, for instance, titanium diboride particles will be provided in the wheel body to function as the cutting particles.

Another aspect of the invention lies in the concept of forming carbonaceous discs in situ during the baking process. For example, plain woven rayon fabric discs may be interlaminated in the mold in place of the graphite discs **11** previously described. During the baking of the wheel in the oven for the **12** hour or more period, the oven is raised to a temperature preferably in the range 850° C.–1350° C. and a thorough carbonization of the rayon fabric laminae, as well as of the pitch, occurs. While woven graphite discs are preferred, cut fibres providing substantially continuous electrically conductive paths may be employed for some grinding operations.

In FIGURE 3 a modified embodiment of the invention is shown in which the wheel body **14** includes carbonaceous materials to an extent such that it will have some electrical conductance properties. For instance, the wheel **14** may be of the nature described in Heald U.S. Patent No. 2,125,782, granted Aug. 2, 1938, wherein sufficient graphite is present to provide a resin bonded wheel with some electrical conductivity. The wheel is formed in the same manner by interlaminating the graphite discs **11'** in the wheel while it is being formed.

In another form of the invention, suited to only some abrading operations and wherein a softer matrix is acceptable, the body **14** of the wheel of FIGURE 3 could be formed with a suitable resin bond but not necessarily with other electrically conductive materials if the interleaved graphite discs **11** are sufficiently close together with a gap between them in the range .005" to .010". U.S. Patent 2,784,812 discloses an illustrative wheel body mix bonded with a phenolic resin. The wheels mentioned with regard to FIGURE 3 are, after pressure forming, heated only to a resin curing temperature.

Instead of the graphite cloth discs **11'**, porous graphite paper discs prepared by raising paper discs to a graphitization temperature in an oxygen-free atmosphere may be used and, in fact such discs may be employed in place of the graphite cloth discs **11** shown in FIGURE 1 to form the wheel of FIGURES 1 and 2. However, graphite discs formed in this manner will not have the porosity of the graphite cloth and will not, it is believed, be as desirable for the purpose. Carbonized paper discs may also be formed in situ in the grinding wheel in the same manner as the carbonized fabric discs mentioned are formed. Further, the graphite fabric discs **11** or **11'** could consist in part of electrically conductive metal fibers or yarn interwoven with the graphitized rayon or cellulosic yarn to provide discs **11** or **11'** having varying electrical properties.

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 I

A carbon-graphite mix containing 45 parts of coal tar pitch and 55 parts of amorphous natural graphite by weight is mixed at 165° C. in a sigma type mixer, and is then cooled and pulverized to 200 mesh size. The pulverized mix is then blended with 100 mesh silicon carbide abrasive grains in a ratio of 50 parts mix to 50 parts grain by weight, and 5 parts silicon by weight to the remainder of the blend is also mixed in. A layer of this pulverulent and intimately blended composition is then deposited in a press die cavity surrounding a hub **12** and a graphite disc, made by raising a plain woven rayon cloth to graphitization temperature in an inert atmosphere, is placed on top of the layer. A second layer of blend is then deposited on top of the flexible fabric disc **11** and the foregoing procedure is continued until a number of discs **11** spaced about .005″ apart are interlaminated in the blend. The final layer is a layer of blend. The press then forms the materials in the cavity into a "green" wheel using a pressure of about 15 tons per square inch and thereafter the wheel is baked slowly in a furnace with an inert atmosphere at a temperature gradually increased to 1200° C. and then gradually decreased over a period of 12 hours.

EXAMPLE II

The composition and method employed in Example I, except that aluminum oxide grains are used in place of the silicon carbide grains.

EXAMPLE III

The composition and method employed in Example I, except that graphitized paper discs are used in place of the graphite cloth.

EXAMPLE IV

The composition and method employed in Example I, except that plain woven rayon cloth discs are used in place of the graphite cloth.

EXAMPLE V

The composition and method employed in Example I, except that graphite cloth having interwoven copper fibers is used in place of the graphite cloth used in Example I.

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. For instance, the invention is well suited to face grinding wheels as well as to peripheral grinding wheels and may be used in the manufacture of arborless grinding wheels.

We claim:

1. A method of preparing an electrolytic machining tool comprising: intimately blending particulate hydrocarbon with abrasive grains and inert filler material; interlaminating flexible graphite body means with layers of said blend to form a raw tool; compressing said raw tool into a rigid body; and slowly baking the body in an inert atmosphere at a temperature sufficient to dehydrogenize the hydrocarbon to form a carbon matrix and bond the grains and graphite body means in the matrix.

2. A method of preparing an electrolytic machining tool comprising: intimately blending coal tar pitch and graphite; partially dehydrogenizing the pitch in the blend to form a solidified carbonaceous mass; pulverizing the mass; blending the pulverized mass with abrasive grains; interlaminating flexible fabric layers with layers of said mass to form a raw tool; compressing the interlaminated

body into a rigid body; and slowly baking the rigid body in an inert atmosphere at a temperature sufficient to substantially completely dehydrogenize the pitch.

3. A method of preparing an electrolytic grinding tool comprising: intimately blending particulate hydrocarbon with abrasive grains; interlaminating flexible, perforate graphite body means with layers of said blend to form a raw tool; compressing said raw tool into a rigid body; and slowly baking the body in an inert atmosphere at a temperature sufficient to dehydrogenize the hydrocarbon to form a carbon matrix which extends through the graphite body means and bonds the graphite body means and abrasive grains in the matrix.

4. A method of preparing an electrolytic grinding wheel comprising: intimately blending coal tar pitch and graphite; partially dehydrogenizing the pitch in the blend to form a solidified carbonaceous mass; pulverizing the mass; blending the pulverized mass with abrasive grains; interlaminating flexible, graphitized, woven fabric disc layers with layers of said mass in the shape of a grinding wheel; compressing the interlaminated body into a rigid body; and slowly baking the rigid body in an inert atmosphere at a temperature sufficient to substantially completely dehydrogenize the pitch.

5. A method of preparing an electrolytic grinding tool comprising: intimately blending particulate hydrocarbon with abrasive grains; interlaminating flexible, electrically conductive body means with layers of said blend to form a raw tool; compressing said raw tool into a rigid body; and slowly baking the body in an inert atmosphere at a temperature sufficient to dehydrogenize the hydrocarbon to form a carbon matrix and bond the grains and electrically conductive body means in the matrix.

6. A method of preparing an electrolytic grinding wheel comprising: intimately blending coal tar pitch and graphite; partially dehydrogenizing the pitch in the blend to form a solidified carbonaceous mass; pulverizing the mass; blending the pulverized mass with abrasive grains; interlaminating flexible, electrically conductive disc layers with layers of said mass in the shape of a grinding wheel; compressing the interlaminated body into a rigid body; and slowly baking the rigid body in an inert atmosphere at a temperature sufficient to substantially completely dehydrogenize the pitch.

7. A method of preparing an electrolytic machining tool comprising: intimately blending bonding material with abrasive grains; interlaminating flexible graphite body means spaced apart about .005″ to .025″ with layers of said blend to form a raw tool; compressing said raw tool into a rigid body; and baking the body at a temperature sufficient to cure the bonding material and bond the grains in the tool.

8. The combination defined in claim **7** wherein the bonding material is a phenolic resin.

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