

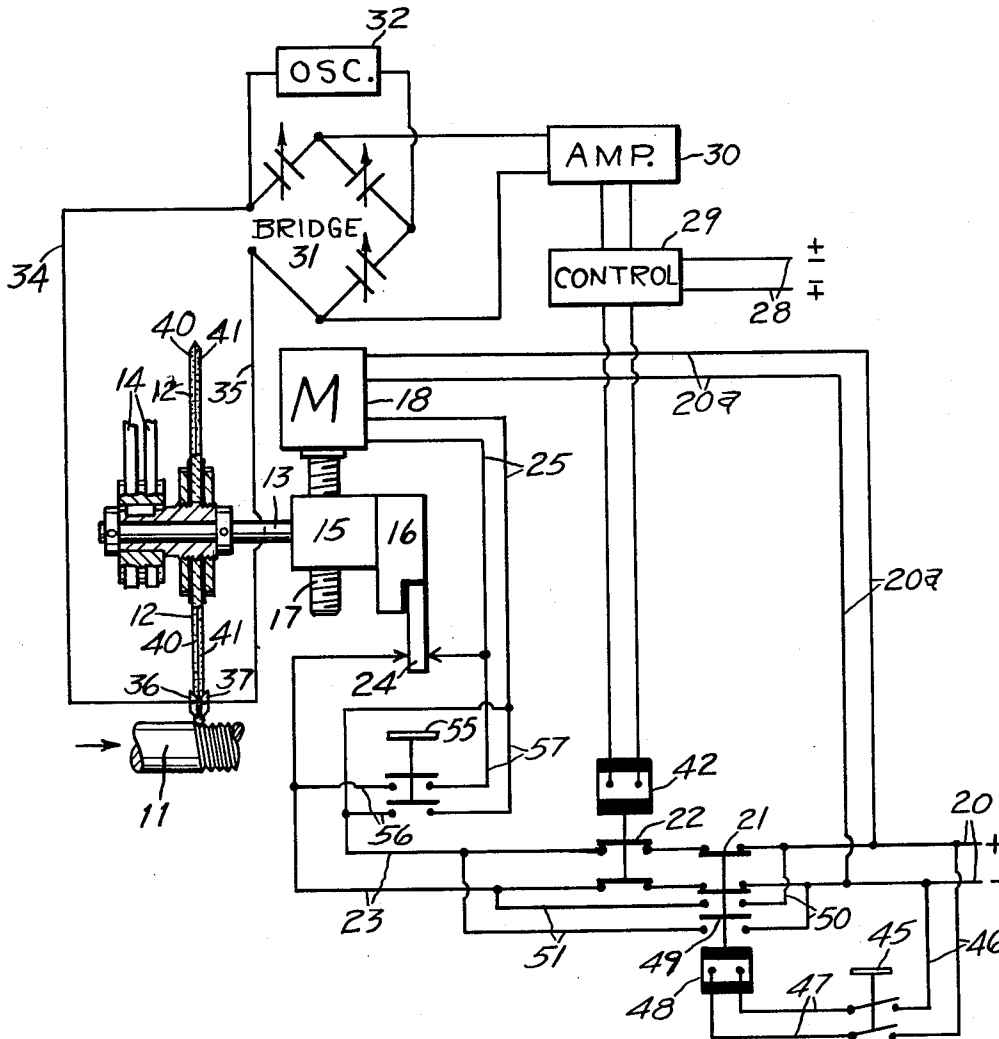
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ELECTRICALLY CONDUCTIVE ORGANIC BONDED GRINDING WHEEL

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ELECTRICALLY CONDUCTIVE ORGANIC
BONDED GRINDING WHEEL

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The invention relates to grinding wheel structure.

One object of the invention is to provide an organic bonded grinding wheel that is electrically conductive with an ohmic resistance suitable for certain machine control operations. Another object of the invention is to provide a process for the manufacture of organic bonded grinding wheels reliably to reproduce wheels having a desired range of electrical conductivity. Another object of the invention is to provide readily practiced processes for the manufacture of such wheels. Another object of the invention is to provide a grinding wheel which can be operated at high speeds and can be used as part of a capacitance sensing device in an automatic machine tool. Another object is to manufacture an organic grinding wheel which has most or all of the customary advantages of organic bonded grinding wheels, such as great strength to resist mechanical shocks and high speeds and adequate grinding efficiency and quality number, at the same time imparting to it enough conductance (reciprocal of resistance) so that it can be used in an electronic control circuit.

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

The accompanying drawing is a block and wiring diagram of a thread grinding machine to illustrate one application for the grinding wheel of the invention.

It is well known that organic materials used to bond abrasive grains for the manufacture of grinding wheels are non-conductive. So high is the resistivity thereof that for all practical intents and purposes they are insulators and very good ones at that. It is also known that the common abrasive, fused aluminum oxide, is non-conductive to the extent of being a good insulator. While silicon carbide, the other commonly used abrasive, is a semiconductor, organic bonded silicon carbide wheels are strictly non-conductive because there is no continuous path for the electric current.

Nor can an organic bonded grinding wheel even with silicon carbide abrasive grains be made electrically conductive by incorporating therein as a filler particles of metal or of graphite and still have practical grinding properties so far as I am aware. If enough of such filler were incorporated to make an electrically conductive path the resultant wheel would not only have poor abrasive characteristics but it would also be so weak as to be unable to withstand the centrifugal force developed at standard grinding speeds measured in surface feet per minute or to withstand mechanical shocks.

I have discovered a way to make a practical organic bonded grinding wheel which is sufficiently electrically conductive for use as a component in an automatic grinder, making available the superior strength of organic bonds as compared with vitrified bonds and having good abrasive characteristics for practical grinding operations.

The commonly used organic materials for the manufacture of grinding wheels are and have been rubber, with sulphur to vulcanize it, shellac, and phenolic resin. Rubber substitutes have been used such as butadiene acrylic nitrile, butadiene styrene and chlorinated butadiene. Many grinding wheels have been made with aniline formaldehyde polymer as a bond and various other aromatic amine polymers have been proposed. Various other or-

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ganic bonds have been proposed in patents and otherwise such as methyl methacrylate and its derivatives.

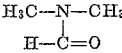
The list of organic materials proposed as bonds for abrasive grains to make grinding wheels is a fair cross section of the plastic polymer art. Inasmuch as the liquid plasticizer used in my invention to make the wheels electrically conductive is compatible with all of these organic materials, which are called plastics and which are polymers, I claim any organic bonded wheel having the material herein specified.

The plasticizers which I have found impart enough electrical conductivity to organic bonded grinding wheels for use in accordance with the purposes of this invention are:

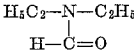
Formamide



Dimethyl formamide



and diethyl formamide



These are collectively known as formamide and its dimethyl and diethyl derivatives.

EXAMPLE

A grinding wheel was made out of the following mixture.

Table	
Material:	Quantity, lbs.
Abrasive—150 grit size white fused alumina	19.7
Bond—	
B stage granular phenolic resin, BR2417	4.48
Powdered graphite, about 220F mesh	2.81
size	2.81
Calcium oxide powder	.85
Plasticizer—dimethyl formamide	360

This wheel was made in the customary way. The 19.7 lbs. of fused alumina was first placed in a mixing pan and wet with the 360 cubic cm. of plasticizer. After each granule of the fused alumina was wet, 6.5 lbs. of the above bond was added and mixing continued until the plasticized abrasive had picked up all of the bond possible and the rest was well distributed. Then the mix was screened and spread in the grinding wheel mold. This mold was placed in a press and hot pressed for one hour at a pressure of two tons per square inch at a temperature of 160° C. After the wheel and mold had cooled and the wheel was stripped from the mold, the wheel was finished. This wheel had a weight per unit volume of 2.76 grams per cc. (specific gravity).

In the table the true bonding material is the phenolic resin, BR2417. This contains enough hexamethylenetetramine to cross link it for curing. The calcium oxide powder is a dehydrating agent, to combine with the water liberated during curing. The graphite is the electrically conductive material according to the invention.

The resistivity of this wheel was 500 ohms cm. and the breaking speed was 27,500 surface feet per minute, a very satisfactory breaking speed. The material selected from the group consisting of formamide and its dimethyl and diethyl derivatives has a specific resistance of less than one megohm cm. but of that order. The incorporation of the graphite therefore vastly reduced the resistivity of the wheel. I use the word "plasticizer" in the

abrasive art sense. Materials which are used to wet abrasive grains so that they will pick up bonding material of any kind are, in the abrasive art, known as "plasticizers." They are liquids. Also any liquid which is mixed with granular solid bonding material for abrasive to make the mix moldable is called a plasticizer. In general the function of a plasticizer in the abrasive art sense is something which makes an abrasive bond mix moldable.

In the final wheel the formamide and its two derivatives stay as such. None of them reacts with the phenolic resin or any of the organic grinding wheel bonds mentioned herein. Each one of formamide, dimethyl formamide and diethyl formamide stays as such in the final wheel after cure. It is distributed as an absorbed liquid therein. Mixtures may of course be used and remain unchanged. The formamide and its dimethyl and diethyl derivatives are plasticizers for the abrasive and bond mix. They are solvents for the uncured phenol formaldehyde, but they are insoluble in the cured phenol formaldehyde resin and each of these liquids separates out on curing. Most organic bonds usable for grinding wheels are soluble in these formamides, but they could be used with a plastic that is not soluble therein.

The conductivity of the wheel made as a component for an electronic circuit to control a grinding operation was much greater than necessary. The wheel will have sufficient conductivity for practical use in some electronic circuits for some sizes of wheels if the resistivity is no greater than one megohm cm. Thus the wheel made had a conductivity of about 2000 times that of the minimum conductivity necessary in this invention. The breaking speed was also greater than necessary for many grinding operations. For many practical grinding operations it will be sufficient if the breaking speed is at least 15,000 surface feet per minute. It is well known that regardless of the diameter of the wheel, if made from a particular composition, it has approximately the same breaking speed. Some differences are caused by different proportions of central hole diameter but this is of such a small order that it is usually ignored.

The size of the wheel was 18" x 3/8" x 10" (diameter, thickness, central hole diameter). It was used in a thread grinding operation about to be described. In the thread grinding machine it was tried to tapered shape as schematically indicated in the drawing.

Wheels according to the invention are useful for controlling grinding operations as illustrated in the diagram of the drawing. In the drawing the work piece 11 is being ground by a grinding wheel 12 made in accordance with the invention. The wheel 12 is mounted on a spindle 13 which is rotated as by means of belts 14. As the drawing is simply a diagram, a feed nut 15 is represented which is connected to a slide 16 to move the spindle 13 forward and back in the direction of the work, the spindle 13 being journaled on the slide 16. The nut 15 is moved by a screw shaft 17 driven by an electric motor 18. Referring now to the lower right of the drawing and working to the left and up, the armature of the motor 18 is energized by power lines 20 through a double relay switch 21, another double relay switch 22, lines 23, a slide controlled switch 24 and lines 25. The slide controlled switch 24 has an insulated element attached to the slide itself which, when it withdraws to a certain point, opens the circuit as diagrammatically indicated.

Referring now to the upper right of the drawing and working to the left and up, the stopping and starting of the motor 18 is controlled by lines 28 through an off and on control 29 energized by an amplifier 30 which receives its signal from a capacitance bridge 31 energized by an oscillator 32. The capacitance bridge 31 is connected by wires 34 and 35 to condenser plates 36 and 37. The other elements of the condensers of which the plates 36 and 37 are parts are the faces 40 and 41 of the wheel 12. When the capacity of the circuit of the bridge 31, wire 34, plate

36, face 49, wheel 12, face 41, plate 37 and wire 35 rises to a certain high value during the feeding of the wheel 12 into the workpiece 5, the signal from the bridge 31 through the amplifier 30 to the control 29 opens the switch 22 by means of relay solenoid 42 which stops the infeed. But when the wheel 12 has been worn away some or trued, thus becoming of less diameter, the capacitances between 36 and 40 and 37 and 41 are lowered and the wheel is fed again toward the work piece to maintain the same depth of cut.

The arrangement shown in the drawing is particularly useful for thread grinding of all kinds and can also be used for surface grinding and cylindrical traverse grinding. Since this invention is in a grinding wheel and a method of producing it. I do not need completely to describe the machine, since the above description is merely to show the utility of the wheel and such machines actually exist.

However the machine should have a circuit to cause the slide 16 to withdraw at the end of a grinding operation. Referring to the lower right of the drawing, a push button switch 45 is connected by lines 46 to the power lines 20 and when closed, through lines 47 energizes a relay solenoid 48 which closes a double relay switch 49 and opens the double relay switch 21. The double relay switch 49 is connected by lines 50 to the power lines 20 and by lines 51 to the lines 23, and it will be seen that the direction of the current is reversed through the double relay switch 49 as compared with through the double relay switch 21. The motor 18 is a reversible motor since the current through its field coils is not reversed as they are connected by lines 20a to the lines 20 not through the switch 49, so when the push button switch 45 is closed the slide 16 retreats, and when it gets to a certain position the switch 24 opens the circuit and the motor 18 stops thus stopping the withdrawal of the slide. Referring to the bottom middle left of the drawing, to start the machine up again the operator momentarily presses a push button switch 55 which connects lines 56 to lines 57, the former being connected to lines 23 and the latter to lines 25. Later the circuit is reestablished through the slide switch 24.

When used in a thread grinding machine of the kind above described, a grinding wheel according to the invention made in accordance with the example ground satisfactorily, had substantially a standard stock grinding rate and a standard wheel wear not at all excessive. This thread grinding was performed upon high carbon steel. The wheel was operated at 9500 surface feet per minute which was standard for phenolic resin bonded wheels. Phenolic resin bonded grinding wheels are now preferred for thread grinding operations where the machine is capable of operating the wheel at a speed of 9500 s.f.p.m. or greater. In the case of old machines which cannot operate with the grinding wheel revolving at the above speed or at higher speeds, vitrified bonded grinding wheels have been preferred. Wheels according to the present invention therefore are useful as components of electronic controlling apparatus and for achieving good grinding performance in modern high speed machines and are better than all others for this purpose.

While so far as I know, there is no limit to the degree of conductivity for a grinding wheel to be used as a component of an electronic circuit of the kind described, by the use of formamide and its specified derivatives together with graphite or other conductive filler material it would be impossible to achieve a conductivity represented by a resistivity lower than about 10 ohms cm., if that. The fact is I do not know the minimum resistivity that can be achieved but if it is necessary to give the lower limit of resistivity this is the best that I can do.

In the mixture any other compatible solid conductive material can be used in place of graphite, for example any metal except those which are liquid such as mercury or highly reactive such as sodium. However there is

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probably no metal that can be used that will not have some adverse effects upon the grinding properties. Iron would be at least in part oxidized in the curing operation. Graphite is the best solid conductor for the mix of which I am aware, but as others can be used, for example magnetite, Fe_3O_4 , I wish to claim them also generically as electrically conductive filler. Magnetite, Fe_3O_4 , has in many grinding operations grinding assisting properties. So also does graphite. Neither are deleterious to any particular extent in grinding operations when incorporated as fillers in small quantities as in the present case. They may of course be used in admixture with each other.

Of the three electrically conductive liquids usable in this invention, I prefer dimethyl formamide. This is less volatile than formamide so less is lost in the curing operation. Diethyl formamide, while quite satisfactory, is not at present commercially available. It would have to be synthesized.

It will thus be seen that there has been provided by this invention an electrically conductive organic bonded grinding wheel and method of making the same in accordance with 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 or shown in the accompanying drawing is to be interpreted as illustrative and not in a limiting sense.

I claim:

1. A grinding wheel or other abrasive article comprising abrasive grains, a cured organic bond bonding said abrasive grains, a filler of solid particles of electrically conductive material selected from the group consisting of graphite, magnetite and mixtures thereof and an electrically conductive liquid selected from the group consisting of formamide, dimethyl formamide and diethyl formamide and mixtures thereof, said cured organic bond being insoluble in said electrically conductive liquid, said article having a conductivity of at least that equal to a resistivity of 1 megohm cm.

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2. A grinding wheel or other abrasive article according to claim 1 in which the electrically conductive liquid is dimethyl formamide.

3. A grinding wheel or other abrasive article according to claim 2 in which the organic bond is phenolic resin.

4. A grinding wheel or other abrasive article according to claim 1 in which the organic bond is phenolic resin.

5. A grinding wheel or other abrasive article according to claim 4 in which the filler is graphite.

6. A grinding wheel or other abrasive article according to claim 4 in which the filler is magnetite.

7. A raw batch for the manufacture of grinding wheels or other abrasive articles comprising abrasive grains, organic bond mixed with said abrasive grains, solid particles of electrically conductive material distributed through said bond, and electrically conductive liquid selected from the group consisting of formamide, dimethyl formamide and diethyl formamide and mixtures thereof, the proportions of the foregoing being such as to give the abrasive article made therefrom a conductivity of at least that equal to a resistivity of 1 megohm cm.

8. A raw batch in accordance with claim 7 in which the organic bond is soluble in the conductive liquid.

9. A raw batch according to claim 8 in which the solid particles are particles selected from graphite and magnetite and mixtures thereof.

10. A raw batch according to claim 7 in which the solid particles are particles selected from graphite and magnetite and mixtures thereof.

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