April 28, 1970 E. L. FONTANELLA 3,508,890

COATED ABRASIVE ARTICLES HAVING PLURAL METAL COATINGS

Filed Jan. 2, 1968

Fig. 1.

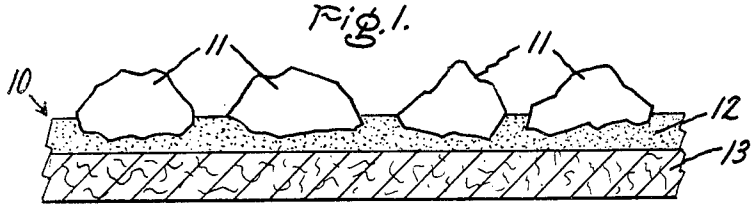


Fig. 2.

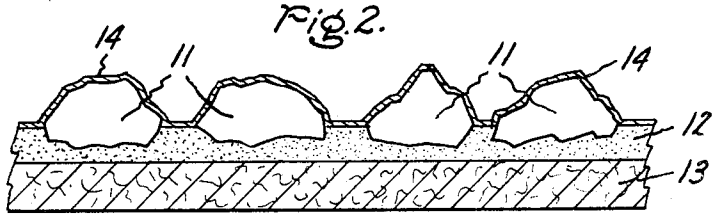


Fig. 3.

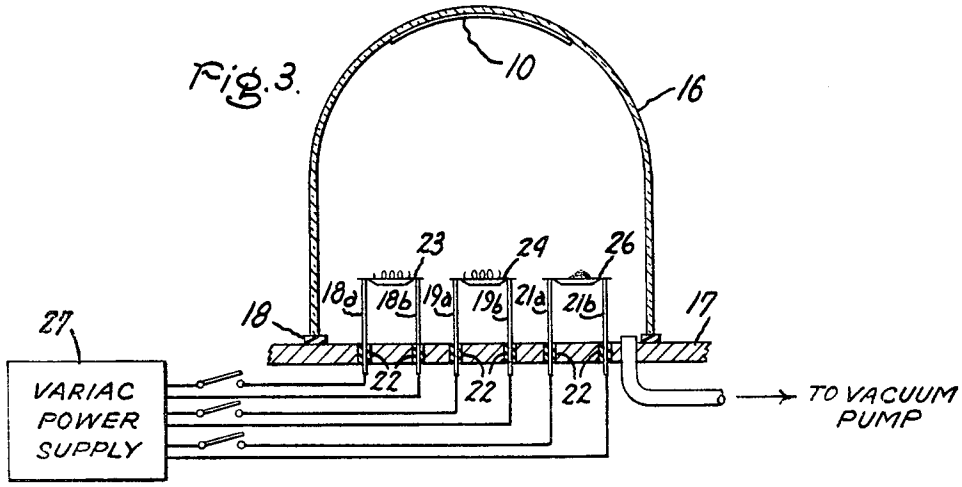
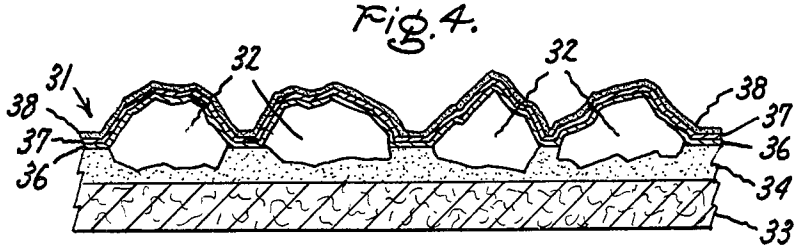


Fig. 4.



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COATED ABRASIVE ARTICLES HAVING PLURAL METAL COATINGS

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ABSTRACT OF THE DISCLOSURE

Improved coated abrasive articles for wet (lubricated) grinding, such as abrasive sheets, belts, discs and the like for polishing hard or soft surfaces are described. These coated abrasive articles are prepared by the vacuum deposition of one layer or a plurality of separate layers in sequence, of oxide-forming metals or of metal oxides themselves over the surface and/or between abrasive grains previously adhered to a waterproof backing material. As many as three different such layers have been employed to provide a reduction in the number of steps normally required in polishing hard surfaces and to substantially increase the life of the abrasive article.

BACKGROUND OF THE INVENTION

Non-metallic bonded coated abrasive articles are commonly made by coating a backing material with an adhesive and distributing abrasive grains over the surface of the adhesive, whereby the grains are firmly attached to the backing upon setting up of the adhesive. A prior, or sizing coating of adhesive is commonly applied over the surface of the abrasive grains to assist in attaching them to the backing. In a variation of the aforementioned method the backing material is coated with a layer of adhesive and a first layer of abrasive grains is applied to the adhesive coating so as to leave a substantial proportion of the adhesive uncovered, a second coating of adhesive is applied over the previously coated surface and then a second layer of abrasive grains is applied.

While most abrasive coated products have employed resins as the adhesive, other adhesives, as for example glue and modified rubber, have been employed. These materials may be employed as solutions, colloidal suspensions or dispersions and they may be normally liquid materials which are heat hardenable, such as certain phenolic condensation products which are liquid when first reacted but which are converted to a solid condition by heating or other treatment.

The abrasive grains may be any of the types commonly employed such as silicon carbide, fused alumina, garnet or flint, diamond or mixtures thereof. Consistent efforts have been expended to increase the cutting rate and lengthen the abrading life of coated abrasive articles. The instant invention provides a substantial increase in both cutting rate and abrading life of the grinding structure by holding the bonded abrasive grains more firmly in place and (in the case of multiple layers of metal and metal oxide) by reducing the number of steps required below those required in a normal polishing sequence thereby also saving operating time.

SUMMARY OF THE INVENTION

In accordance with the broadest aspect of the instant invention, a layer of a strong, easily evaporable and inexpensive oxide-forming metal is deposited by evaporation over the exposed surfaces of the abrasive grains of a non-metallic bonded coated abrasive article.

In the case of coated abrasive articles (both metal bonded and non-metallic bonded) employed for polishing operations, an initial abrasive particle-anchoring metal

layer deposited by evaporation is covered with one or more additional layers deposited by evaporation with the exposed (top) layer being a coating of metal with an oxide formed thereon or a coating of deposited metallic oxide. The structure so produced makes possible a simultaneous grind and polish action and readily brings hard surfaces to a semipolished state in a single operation.

BRIEF DESCRIPTION OF THE DRAWING

Other objects, features, and advantages of the invention will appear more clearly from the following detailed description of the preferred embodiment thereof made with reference to the drawings in which:

FIG. 1 is a sectional view through a portion of a coated abrasive article comprising a waterproof backing coated with an adhesive and abrasive grains, the latter being shown in elevation;

FIG. 2 is a sectional view similar to FIG. 1 wherein a coating of metal has been deposited by evaporation over the abrasive surface of the article;

FIG. 3 is a view in section of an apparatus for applying coatings of metal or metal oxide by evaporation; and

FIG. 4 is a sectional view similar to FIG. 1 through a coated abrasive article for simultaneous grinding-polishing operations showing the plurality of layers deposited in sequence, as for example, over the coated abrasive article of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring to the drawing, FIG. 1 illustrates a coated abrasive article **10** such a structure is ordinarily available on the commercial market. A facing of abrasive granules **11** are bonded by adhesive layer **12** (which may be metallic or non-metallic) to the surface of a water-resistant support or backing sheet **13** made, for example, of felted cellulose or paper-board. The backing **13** should be strong in tension and, in the case of flexible abrasive sheets and belts, should be resistant to repeated bendings.

FIG. 2 shows a reinforced grinding structure produced by applying only a single layer **14** of a metal selected from the group consisting of aluminum, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, iron, manganese, nickel and silver by evaporation deposition over a conventional grinding structure wherein the adhesive is non-metallic and, therefore, more in need of the added particle-retention capabilities of layer **14**. Layer **14** should have a thickness ranging from about 1500 to about 10,000 angstrom units (A.). Layers in this thickness range deposited by vacuum deposition are very dense and are very effective for reducing abrasive particle pull-out.

When aluminum is used for layer **14**, Al_2O_3, which will function as a polishing material, forms on the surface almost immediately upon exposure to air. Many of the other metals form oxide surfaces upon being heated in air.

Coating of an abrasive article, such as article **10**, with metal is accomplished in the apparatus illustrated in FIG. 3 wherein a vacuum evaporation process is employed. In the conduct of the evaporation process deposition, the surface of article **10** is first cleaned of surface impurities by washing with alcohol or any ordinary detergent material and then rinsing, as for example with distilled water. After drying, article **10** is placed within vacuum chamber **16**, which may be a glass bell jar, supported on a suitable base **17**, seal **18** being interposed therebetween. Metal conductors **18***a*, **18***b*, **19***a*, **19***b* and **21***a*, **21***b* extend through and are electrically insulated from the base **17** by means of electrical insulators **22**. Each pair of metal conductors support at the upper ends thereof a boat of a high melting point, high resistance material suspended between them.

Thus, boat **23** of a metal such as tantalum is suspended between conductors **18***a*, **18***b*. Similarly boats **24** and **26** are suspended between the other conductors as shown. Each boat **23**, **24**, **26** will hold an appropriate metal or metal oxide so that the desired layers can be applied in sequence to article **10** in jar **16**. This arrangement of sequential deposition without exposure to air has the advantage that more tenacious bonding is obtained between subsequent layers.

The chamber **16** is evacuated to at least about 4×10^{-5} torr. Metal conductors **18***a*, **18***b*, **19***a*, **19***b* or **21***a*, **21***b* may be selectively connected to a source of low variable voltage electric current, e.g. Variac power supply **27**. Upon passing current through one or the other of boats **23**, **24**, **26** the contents of the boat is heated and evaporates to produce molecules, which impinge and are deposited on the exposed surfaces of article **10**. When the desired thickness of metal has been deposited the heating of that particular boat is stopped.

The metal-coated abrasive body may be removed at this point (single metal layer) to produce the structure in FIG. 2. If, on the contrary, additional layers are to be deposited in order to prepare a grinding-polishing body, the first layer may be of any of the aforementioned easily evaporable, strong, inexpensive metals and a second layer may be applied selected from the group of metals consisting of indium, lead or tin, each of which will promptly produce the respective oxide (a polishing material) over its surface upon exposure to air. If this is to be the last layer applied, this second layer deposited by evaporation may also be any of the following oxides (or mixture thereof): Al_2O_3, Sb_2O_3, Bi_2O_3, CdO, Cr_2O_3, Fe_3O_4, Fe_2O_3 and SnO_2. Each of these latter oxides are polishing compounds and in a two layered abrasive structure will give an accepted combined grinding-polishing action in combination with the abrasive particles receiving increased anchorage from the first layer applied thereto.

FIG. 4 illustrates a multi-layered abrasive article **31** for use in a superior lubricated grinding-polishing operation. Such an article would preferably consist of a total of three layers applied by evaporation over the abrasive grains **32** adhered to backing **33** by layer **34**, which may be any of the conventional adhesive materials mentioned hereinabove or conventional metallic bonding mediums. Layer **36** (the same as the first layer materials referred to hereinabove) is applied to further anchor abrasive grains **32**; layer **37** selected from the group consisting of indium, lead and tin is applied specifically to generate a lapping structure in combination with layer **38**, which is a layer of polishing material. Layer **37** may consist of any of the following oxides: Al_2O_3, Sb_2O_3, Bi_2O_3, CdO, Cr_2O_3, Fe_3O_4, Fe_2O_3, SnO_2 and mixtures thereof and constitutes the outer layer of the configuration of FIG. 4.

Conventional laps are made from materials, which at least serve as the host for polishing particles which become embedded therein during the polishing operation from a layer of polishing compound (e.g. SnO_2, Ce_2O_3, MgO, ZnO_2, Cr_2O_3, Fe_2O_3, tripoli) applied thereover. Some laps are made of materials, which in addition to the aforementioned function also perform a second function; namely, readily forming and contributing polishing material to the polishing operation as polishing proceeds. Examples of laps in the first category are hardwood maple laps, canvas laps, Lucite laps. Examples of laps in the second category are tin laps, lead laps and pitch and beeswax.

In normal wet polishing procedures (as for example in the preparation of mineralogical specimens) a sequence of operations all of which employ some lubricant (e.g. water, oil, vinyl stearate) is conducted as follows:

(a) Rough grinding using 200 grit disc (particles are coarse, passing through #200 U.S. Sieve size); grains of abrasive are either pulled out or the tips are knocked off, after which the disc must be discarded;

(b) Finer grinding using 400 grit disc;

(c) Still finer grinding using 600–1800 grit discs to achieve the equal of a satin finish; as succeedingly finer grit sizes are used the manipulation actually conducted is the constant reduction in the size and depth of scratches remaining from the rough grind; and

(d) Polishing using a lap of the type described hereinabove; during polishing decreasing amounts of lubricant liquid are used to enable the buildup of heat to produce what may be a flowing action to move surface material to cause filling in of remaining very small surface mars.

In contrast to the above, use of the structure covered with the three layers (FIG. 4) results in combined grinding and polishing operations simultaneously executing steps (a), (b) and (c) above to actually exceed a satin finish quality and produce a semi-polished finish. Not only is there the savings in time of being able to reach a semi-polish of hard substances in a single operation, but the life of the grinding structure is increased at least five fold still retaining the capability for simultaneous grinding and polishing throughout. During use, the outer oxide layer becomes embedded in the second layer of lap material and at the same time the tips of abrasive particles are exposed to provide the grinding. The presence of the first layer as discussed hereinabove retains the grains longer and this is reflected in the considerable increase in the life of the abrasive body. In a typical structure embodying the lap construction in combination with the grinding structure, layer **36** is aluminum, layer **37** is tin and layer **38** is bismuth trioxide. Although thicker layers may be employed, it has been found that a thickness of aluminum ranging from about 3000 to about 5000 A. and a thickness of tin and bismuth trioxide each equal to about 5000 A. is satisfactory. As has been indicated hereinabove the evaporated aluminum layer functions to hold the bonded abrasive particles more firmly in place thereby considerably increasing the life and cutability of the grinding-polishing tool; the tin layer serves to simulate a lapping plate ordinarily used to receive a slurry of powdered oxides and the bismuth trioxide layer provides the requisite polishing medium, which becomes gradually embedded in the tin layer creating a lap structure during use. In addition, the rate of wear of the top layer is visible, because depending upon the thickness of the Bi_2O_3 layer (Bi_xO_3, a mixture of bismuth trioxides, may be used) its color will vary from yellow to deep purple, the yellow being the thin layer.

In experiments performed to see whether the presence of the evaporated metal layer **16** would contain the abrasive points **13** longer and whether the grinding and polishing action would be enhanced by the presence of the evaporated metals and oxides, controls were established to provide a basis of comparison.

One control consisted of a 600 grit resin-bonded wet back silicon carbide paper (without metal coating). This paper was used to finely abrade one sample each of rutilated quartz, Brazilian agate and Mexican lace agate, a total of three sawed mineralogical specimens to which the silicon carbide paper was applied in sequence. Water was used as the lubricant-coolant. Each specimen progressively wore the silicon carbide grit and pulled abrasive grains from the resin bonding agent. The total abrading time for the three samples was 1½ hours. Microscopic examination (45×) of the control 600 grit silicon carbide paper showed both significantly large abrasive grain loss and substantially worn out silicon carbide.

Another 600 grit resin-bonded wet back abrasive paper was coated by evaporation with a first layer of from about 3000 to 5000 A. of aluminum, a second layer of from about 3000 to about 5000 A. of tin and a third layer of about 5000 A. of bismuth trioxide. Water was used as the lubricant-coolant and five samples of each of the three materials listed above were polished with this modified silicon carbide paper. These samples were cut from the same specimens as in the control. Each of the 15 samples was sanded, prepolished and polished to a stage significantly beyond the abrading, or sanding, which

was accomplished with the control silicon carbide paper. At this point in time the modified paper could have been used for still more one-step polishing but further use thereof in this manner was prevented by the accidental catching and tearing of the paper.

The silicon carbide paper receiving the coatings as described above was taped in place during the evaporation process and as a result four small areas near the rim of the paper remained unmodified. Care was taken not to work these areas during the aforementioned grinding-polishing, which consumed a total work time of 5 hours. As a further control the condition of the silicon carbide particles in the modified/worked area was compared to the condition of the silicon carbide particles in the unmodified/unworked areas after the 15 samples had been polished. Comparison was by microscopic examination (45×) and it was found that the silicon carbide grains in the worked area were still quite sharp and well-contained and bismuth trioxide remained between the silicon carbide particles covering the tin and aluminum layers.

Thus, the instant invention has been shown to reflect cost savings and/or time savings in several improved constructions of coated abrasive articles, the depositions being by evaporation in each case:

(a) In the case of 400 grit and coarser abrasive particles bonded with non-metallic adhesive a single layer of metal selected from the group consisting of aluminum, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, iron, manganese, nickel and silver;

(b) In the case of 400–600 grit abrasive particles held in place with either a metallic or non-metallic bonding medium a double layer is applied; the first layer is as in (a) above and the second layer is selected from the two groups consisting of indium, lead, tin, and mixtures or alloys thereof on the one hand and alumina, antimony oxide, bismuth trioxide, cadmium oxide, chromium oxide, ferrous oxide, ferric oxide, stannic oxide and mixtures of these oxides on the other; and

(c) In the case of 400 grit and finer abrasive particles held in place with either a metallic or non-metallic bonding medium a triple layer is applied; the first layer is as in (a), the second layer is selected from the group consisting of indium, lead and tin and mixtures or alloys thereof and the third layer is selected from the group consisting of alumina, antimony oxide, bismuth trioxide, cadmium oxide, chromium oxide, ferrous oxide, ferric oxide, stannic oxide and mixtures thereof.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In an abrasive article for lubricated grinding wherein a backing has an adhesive thereon, a coating of particles of abrasive material on said backing directly adhering to said adhesive and a layer of metal covering said coating of abrasive particles, the improvement comprising the addition to said combination of a second layer of material contiguous to the layer of metal, said layer of metal being of a metal selected from the group consisting of aluminum, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, iron, manganese, nickel and silver and said second layer being of a material selected from the group consisting of indium, lead and tin and mixtures and alloys thereof whereby the composite structure may be used to accomplish simultaneous grinding and polishing of hard surfaces.

2. In an abrasive article for lubricated grinding wherein a backing has an adhesive thereon, a coating of particles of abrasive material on said backing directly adhering to said adhesive and layer of metal covering said coating of abrasive particles, the improvement comprising the addition to said combination of a second layer of material contiguous to the layer of metal, said layer of metal being of a metal selected from the group consisting of aluminum, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, iron, manganese, nickel and silver and said second layer being of a material selected from the group consisting of alumina, antimony oxide, bismuth trioxide, cadmium oxide, chromium oxide, ferrous oxide, ferric oxide, stannic oxide and mixtures thereof whereby the composite structure may be used to accomplish simultaneous grinding and polishing of hard surfaces.

3. In an abrasive article for lubricated grinding wherein a backing has an adhesive thereon, a coating of particles of abrasive material on said backing directly adhering to said adhesive and a layer of metal covering said coating of abrasive particles, the improvement comprising the superimposition over said combination of second and third layers of materials, said second layer being contiguous to the layer of metal and said third layer being contiguous to said second layer, said layer of metal being of a metal selected from the group consisting of aluminum, antimony, bismuth, cadmium, chromium, cobalt, copper, gold, iron manganese, nickel and silver; said second layer being of a material selected from the group consisting of indium, lead and tin and mixtures of alloys thereof; and said third layer being of a material selected from the group consisting of alumina, antimony oxide, bismuth trioxide, cadmium oxide, chromium oxide, ferrous oxide, ferric oxide, stannic oxide and mixtures thereof whereby the composite structure may be used to accomplish simultaneous grinding and polishing of hard surfaces.

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