Dec. 21, 1948. F. A. UPPER 2,457,012

ABRASIVE ARTICLE AND METHOD OF MAKING

Filed June 27, 1944

Fig. 1.

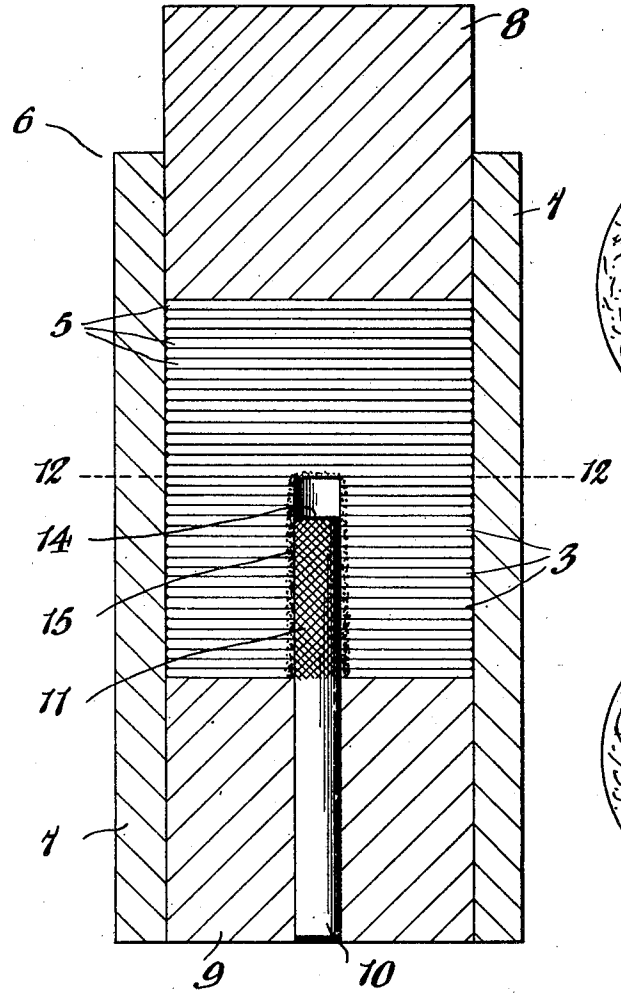


Fig. 1b.

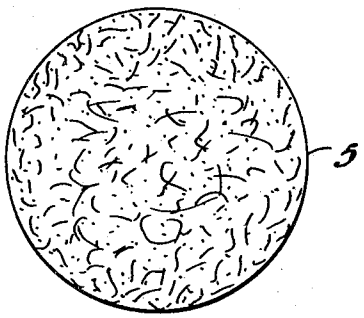


Fig. 1a.

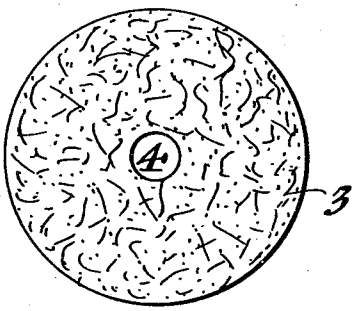
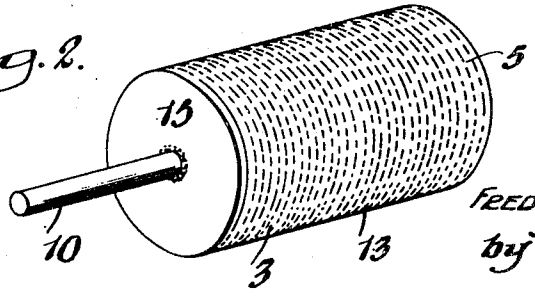


Fig. 2.



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ABRASIVE ARTICLE AND METHOD OF MAKING

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Application June 27, 1944, Serial No. 542,323

5 Claims. (Cl. 51—193)

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This invention relates to abrasive articles and methods for their manufacture. More particularly, it relates to resilient abrasive articles of the bonded type such as mounted abrasive points, wheels, tools and the like, formed from a plurality of layers of an abrasive-containing, felted fibrous sheet material, compressed and permanently mounted upon a suitable spindle or shaft. The articles of the present invention are characterized by having a uniform density and hardness grade throughout the abrading body and a mild or "soft" abrading action which combines an effective cutting rate with an efficient and satisfactory polishing action. The invention especially pertains to methods of fabricating such mounted abrading devices of "soft" cutting and polishing action whereby the abrading bodies are not only of uniform character throughout but are securely and firmly held upon the mounting spindles or shafts with an improved strength and durability.

There has always been a need for abrasive articles of the bonded type which would combine an effective cutting action with satisfactory finishing or polishing whereby a reasonable amount of material would be removed from the work being abraded and at the same time the article would be left with a desirable surface finish or polish. Abrasive articles heretofore provided for such dual purposes have failed to be completely satisfactory in accomplishing both goals and have been found to be defective in one respect or another. Among the reasons for their unsatisfactoriness have been the failure to combine an appreciable degree of cutting ability with a resilience or "softness" of cutting action, non-homogeneity of the abrasive article, lack of permanency of the abrasive content (i. e., failure of the abrasive wheel structure to retain the abrasive particles within the abrading body), non-uniformity of abrasive action, inflexibility, etc. Provision of satisfactory properties in one respect has usually been at a sacrifice of one or more of the other characteristics desirable in such products.

Ordinary bonded abrasive articles of the prior art consisting of abrasive grains and a binder therefor in which various fibers have been incorporated for reinforcing means or for other purposes, on account of their harsh, hard cutting behavior have never been found suitable for the purposes herein set forth. They do not provide an action equivalent or comparable to the combined "soft" cutting and polishing action of the present articles.

Recently, abrasive articles have been made

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from abrasive-included, fibrous sheet material by processes in which fibrous sheet material has been cut in the form of long strips which are spirally wound in convolutions and compacted to make the desired abrasive article. While these articles have shown a resilient cutting action of the desired type they have retained a defect of the convoluted structure which it is desirable to avoid, that is, the process of making such articles by said methods results in the convoluted articles having flash markings along the sides, i. e., an area on opposite sides of the article after it has been compacted where the convolutions of sheet material have been compressed to a higher degree than the rest of the body, leaving that part of the article one or more grades harder in grinding action than the remainder of the article.

Other articles have been formed from disc-shaped plies of similar fibrous sheet material of the size and shape of the final abrasive articles, which plies have been superimposed on one another and compacted to form abrasive wheels, discs and the like of a layered construction. While the ordinary solid or arbored abrasive grinding and polishing wheels and shapes of this latter construction have shown a resilient cutting action of the desired type wherein an efficient and effective cutting rate and a satisfactory polishing action have been combined, satisfactory methods have not been known for making similar abrasive articles of the mounted variety wherein the abrading element or body is permanently mounted on a suitable spindle or shaft. Failure to satisfactorily produce such mounted articles has been due primarily to the inability to secure or fasten the abrading body upon the mounting spindle or shaft with sufficient strength to retain it rigidly and firmly in position without loosening, and at the same time preserve the original resilience or "softness" of cutting and polishing action of the fibrous, abrasive-containing body mounted upon the spindle.

I have discovered a method of making such mounted abrasive articles, and especially involving a procedure of mounting the abrasive body upon the spindle or shaft therefor, whereby the spindle or shaft is strongly and durably secured within the abrasive body for the natural abrading life of the article and at the same time all of the original resilience or "softness" of cutting and polishing action of the abrading element is retained.

In accordance with the present invention mounted abrasive articles of the resilient or "soft" acting type which combine cutting ability with

a polishing action are made by a process in which an abrasive material in the form of a felted fibrous web having abrasive grains and adhesive binder included internally thereof, is cut to the desired shape and size and the resulting pieces assembled and compressed about a mounted spindle or shaft to form the desired abrasive article. The abrasive and adhesive content of the fibrous material is incorporated and distributed throughout the fibrous web at the time of its manufacture and constitutes an integral part thereof. This fibrous abrasive web material can be satisfactorily made in a number of ways, as will be set forth later. Although the abrasive-containing fibrous sheet material has some adhesive included therein which may suffice for the making of certain abrasive articles, an additional adhesive usually, and preferably, is incorporated with the fibrous sheet material, as a sizing applied to one or both sides of the abrasive included sheet material prior to its assembly, either before or after it has been cut to the desired size and shape for assembly. The adhesively sized sheets of abrasive included material are assembled and given an initial compressing, such as by cold-pressing, and prepared for reception and retention of the spindle by being provided with a re-entrant or spindle-receiving part which is primed or sized by the application of a coating of adhesive which is then usually dried. The spindle is likewise prepared for mounting by roughening the surface of the portion to be inserted in the abrasive body as by either sandblasting or knurling, after which it is likewise sized with a light coating of an adhesive cement similar to that used for sizing the re-entrant portion of the assembled abrasive sheet material and also dried. The spindle and abrasive body as above prepared are then placed in a suitable mold and compacted, as by the application of heat and/or pressure, to secure the spindle and form the mounted abrasive article. The compacting step is usually followed by a short oven cure, after which the abrasive article is trimmed or dressed to remove any surface irregularities or blemishes, whereupon it is ready for use.

In order to better understand the nature of the invention, reference is made to the accompanying drawings in which:

Figure 1 shows a vertical cross section through a mold for forming the mounted abrasive polishing point shown in Figure 2, including a schematic picturization of the manner of assembling the spindle and abrasive body elements of the article for the final compacting or molding operation;

Figure 1*a* is a top plan view of one of the individual ring-shaped elements **3** of an abrasive included fibrous sheet material which make up that part of the abrasive body below the point **12** of Figure 1 and surrounding the knurled portion of the spindle;

Figure 1*b* is a top plan view of one of the individual disc-shaped sheets of abrasive included, fibrous sheet material which make up that part of the abrasive body above the point **12** of Figure 1; and

Figure 2 shows a finished mounted polishing point made in accordance with the present invention.

The abrasive-included fibrous web material used in making the products of the present invention can be manufactured in several ways. A very satisfactory method of making included abrasive sheet material of the herein required type is that set forth and fully described in U. S. Patents Nos. 2,284,715 and 2,284,716. Briefly, the felted fibrous web is formed by feeding a plurality of thin carded fibrous membranes from a number of carding assemblies onto a moving endless support so that each membrane is deposited or superimposed upon the preceding membranes until a web of loosely felted fibrous material of the desired thickness is built up on the traveling support. A number of abrasive grain hoppers are also disposed between the carding assemblies and above the traveling conveyor. Abrasive grain is fed from the hoppers onto the fibrous membranes at various stages in the building up of the final web, so that, as a result, the abrasive material is applied between the individual membranes making up the web and so is internally distributed throughout the fibrous web or sheet. A suitable adhesive binder is then incorporated within the fibrous-abrasive web and the web is consolidated to a desired density and passed to a curing zone, where the adhesive is matured or set. The included abrasive web is then wound into rolls for use as a source material for the manufacture of the products herein described.

In practicing the invention, any of the abrasive materials in common use may be employed, such as silicon carbide, diamonds, boron carbide, fused aluminum oxide, flint, corundum, emery, rouge and similar substances. The size of the abrasive particles may vary from the finest polishing or buffing powders to the coarser grit sizes used in grinding.

Other methods of incorporating abrasive material internally of the fibrous sheet material during its manufacture may be employed. For example, the abrasive particles can be thoroughly admixed with the adhesive binder and the mixture applied to the uncompacted web by the usual adhesive-applying rolls. This method has been found to be particularly satisfactory for the inclusion of the finer abrasive materials of the size employed in buffing and polishing operations.

Another method is to project the abrasive material into the web or sheet after it has been built up to the desired thickness and immediately prior to consolidating the web. The projection of grain is suitably carried out by means of a blast of air or gas against one or both surfaces of the fibrous web, the air stream being laden with the abrasive material to be included internally of the web. The other steps in the formation and consolidation of the web are carried out in a manner similar to that used in the previous procedures.

Felted fibrous webs having abrasive material included within the web and which are suitable for use in the fabrication of the herein described products can also be made by a modification of the above processes in which the individual fibers are interwoven and interlocked by a gentle air or gaseous agitation of the thin carded membranes during their deposition. This process is termed "aerodynamic weaving" and is used to promote the strength and eliminate any laminations from the web. For a more complete description of such a process and product, reference is made to U. S. Patents Nos. 2,284,738 and 2,284,739 in which further details are also given of the above procedures for including abrasive materials within the fibrous structures.

Abrasive included sheet material of the herein required type can also be made by wet-felting procedures employing the various types of paper-stock fibers and including abrasive therein at the time of making the sheet material. One satisfactory method of making an abrasive included sheet

material by wet-felting procedure is that set forth and fully described in co-pending application Serial No.. 554,273, filed September 15, 1944.

Briefly, the felted fibrous paper stock material having abrasive grain incorporated internally thereof is made by first forming a liquid, usually aqueous, suspension of fibrous material, the fiber content of the suspension being very low and in the neighborhood of 0.5 to 5% of the suspension, collecting the fibrous suspension on a suitable support, introducing abrasive grains with or without an adhesive binder into the fibrous web while it is in a highly aqueous, or fluid, condition, extracting the water or other liquid medium from the web, and further drying and compacting the web to the desired density. Optionally, the abrasive grains can be given a preliminary coating of a suitable adhesive, which is preferably soluble or softenable in the liquid suspending medium or a component thereof, to assist in holding the fibrous abrasive-containing web in compacted form after it has been compressed. The process can be carried out in a number of ways.

In one such modification the fibrous suspension of paper-stock is deposited upon a foraminous support in one step and the abrasive grain is deposited in several increments while the web is still in a highly aqueous or fluid condition. That portion of abrasive applied first penetrates deepest into the web structure, and the abrasive of each succeeding deposition penetrates the web to a lesser degree by reason of the continually decreasing amount of water present and the consequent thickening of the fibrous body. The distribution of abrasive within the web can thus be controlled by variation of the amounts and places of deposition during the dewatering of the web so as to obtain any desired effect.

In a modified form of the process a fluid fibrous suspension is collected upon a plurality of revolving foraminous supports, such as cylinders, which are partially immersed in the fibrous suspension. The thin fibrous membranes collected upon the foraminous supports are then successively transferred to a common carrier, usually a moving endless felt blanket or belt, in superimposed relationship to form a fibrous web structure. Abrasive grain is incorporated into the fibrous web structure by deposition or projection between and into the various individual membranes as they are deposited on the carrier support. This method has the advantage that, since the fibrous suspensions can be varied, the composition or structure of various portions of the web can be varied if desired. Adhesive binders can be incorporated in the fibrous web, regardless of the procedure used, at various stages in the process, such as by inclusion in the fibrous suspension, introduction during dewatering of the web, with the abrasive grains as a coating thereon, or after the web has been substantially dewatered and prior to the final compacting and drying of the web.

A still further modification which can be used to make fibrous abrasive materials is the process of forming a wet fibrous abrasive lap by a cylinder wet-press process, in which a fibrous suspension similar to that used in the cylinder method above is fed, usually from a single cylinder mold, onto a traveling wet felt carrier belt. The thin fibrous membrane is conveyed over one or more suction boxes to remove a portion of the water and passed between a pair of pressure rolls. As the fibrous material passes between the pressure rolls it is transferred to the upper pressure roll upon which it is wound in a series of successive layers until the desired thickness of fibrous material is obtained, whereupon the material is removed by hand or by a suitable knife or doctor blade. Abrasive grain is fed onto the fibrous sheet previous to its passage between the pressure rolls and is thereby incorporated within the fibrous structure.

Another satisfactory method of making included abrasive paper-stock sheet material is that set forth and fully described in co-pending application Serial No. 461,140, filed October 7, 1942, which issued as Patent No. 2,418,282, dated April 1, 1947.

In accordance with the process therein set forth, fibrous paper-stock, abrasive-included sheet material is made from an aqueous suspension of around 3% fiber content in which the fibers are distributed in the suspension as substantially individually separated fibers. This fibrous suspension is agitated, beaten, or otherwise mechanically treated, with sufficient vigor to render the fibers partially gelatinous, and abrasive grain is incorporated in the suspension to the desired extent. A sufficient amount of abrasive grain is added to provide an abrasive grain content of over 40%, and preferably 60–70% or more by weight of the final product after the water has been extracted. The agitation of the fibrous suspension previous to and/or during the addition of abrasive grain is very important in preparing a liquid in which the abrasive particles will remain uniformly in suspension. This stability of suspension is believed to be due, at least in part, to the adherence of the abrasive particles to the partially gelatinized fibers. The amount of agitation or beating of the fibrous suspension necessary to provide a suitable stable mixture of abrasive and fiber of the proper consistency depends upon the size of the abrasive particles. For example, a very slight agitation serves the purpose when the finest abrasive polishing powders are used whereas with the use of 60 or 80 grit abrasive grains it is desirable to subject the suspension to a much longer and/or more vigorous agitation. Suspension of the abrasive particles may be assisted by incorporating an adhesive in the fluid mass, either in the form of a preliminary coating of the abrasive particles or by the addition of the adhesive to the liquid. In either case, the adhesive should preferably be soluble in the liquid medium of the suspension or at least sortenable or soluble in a component thereof.

After a fiber-abrasive suspension of suitable consistency has been prepared as above outlined, it is flowed or otherwise deposited onto a suitable foraminous support in the form of a continuous, highly aqueous layer from which the water or other liquid suspending medium is extracted, and the resulting film is further dried and compacted to the desired density. These operations can be performed by flowing the suspension onto a moving endless wire screen or by collecting a plurality of thin membranes onto cylinder molds and transferring them to a suitable felt blanket in superimposed relation to form a web of the desired thickness. While it is usually desirable to proceed in the described manner of forming continuous fibrous webs by this particular method, the process can be practiced in modified form by using the same thin suspension of fibers and abrasive to form individual abrasive-included sheets by a series of discontinuous steps. Adhesive binders can be incorporated in the fibrous web, regardless of the procedure used, at various stages in the process, such as by inclusion in the fibrous sus-

pension, introduction during dewatering of the web, as a coating on the abrasive grains, or after the web has been substantially dewatered and prior to the final compacting and drying of the web.

Modifying agents such as waterproofing compounds, anti-friction agents, flexibilizers, plasticizers and other fillers may be incorporated in the web at the time of making, irrespective of the particular procedure followed, in order to render the web resistant to water or impart other specific desirable properties to all or certain controlled portions of the web.

The abrasive-included, felted fibrous web material, such as that made by any one of the aforementioned methods, is used as a source of raw material for the making of mounted abrasive articles. As a specific example of the manner in which the present process has been carried out and abrasive articles made in accordance with the teachings of the present invention, the following procedure is given.

A flexible, felted fibrous sheet material made in accordance with the teachings of U. S. Patents Nos. 2,284,738 and 2,284,739, and containing approximately 75% of fused alumina particles of 80 mesh grit size, 15% cotton fibers and 10% natural rubber derived from latex was sized with a 20% aqueous solution of "Casco" glue (which is a casein glue marketed and sold by Casein Corporation of America) to provide about 10% casein by weight based on the fibrous sheet material. This sized material was dried and then cut to the desired size and shape for use in making the abrasive article. In the illustrated example a number of ring-shaped sheets **3**, having a died-out central arbor hole **4**, such as is shown in Figure 1*a*, were cut from the sheet material for forming that part of the abrasive body surrounding the embedded portion of the spindle; also, a number of disc-shaped sheets **5**, such as shown in Figure 1*b*, were cut from the same sheet material for use in forming the balance of the abrasive body. Instead of adhesively coating the abrasive sheet material prior to cutting to size, the sheets can be coated with the desired adhesive after it has been cut to size, although the former method is preferred because of the greater facility of applying the adhesive coating and drying the material in roll form.

More recently, improved methods of handling the application of adhesive and cutting of the sheet material to the ultimate size for use in forming the abrasive bodies of the desired shape have been devised. These improved methods have been more fully set forth and described in my co-pending application Serial No. 542,324, filed June 27, 1944, which issued as Patent No. 2,375,263, dated May 8, 1945; they are applicable to carrying out the present invention and, in fact, constitute the preferred method of applying adhesive and cutting of the sheet material. Briefly, the abrasive-included fibrous, sheet material is first sized in roll form or in the shape of relatively large sheets of the material, after which a sufficient number of the large sheets of the adhesively sized material are assembled in superimposed relation to provide a slab of specified thickness, as for example ¼'' thick when compressed, as by cold-pressing. The number of individual sheets to be used in forming one of the compacted slabs is determined by weighing. In the case of the herein illustrated example the preformed slabs of sheet material are then died out on a punch press or similar mechanism, or cut or punched out by hand, to provide a number of discs or ring-shaped segments of slab thickness. Each segment consists of a number of individual sheets of abrasive-included fibrous web material of the size and shape shown in Figures 1*a* and 1*b*, respectively, preliminarily compressed and ready for use in making the molded abrasive article.

Referring further to the drawings, Figure 1 shows a diametrical, vertical cross-section through a mold **6** containing an assembly prior to the final compression of the elements constituting a mounted abrasive polishing point such as that shown in Figure 2. The mold consists of a barrel **7**, the top plunger **8** and a split bushing **9**. As the mold is set up for assembly of the abrasive article from its components, the split bushing **9** is provided with a metal spindle **10** having a knurled or otherwise roughened surface **11** for strongly and firmly gripping the surrounding ring-shaped elements of sheet material **3**.

Prior to insertion in the mold set-up, the spindle in addition to being roughened by sand-blasting, knurling or similar operation, is given a thin coating of adhesive and dried to set and fix the adhesive upon the spindle. A suitable liquid adhesive for this purpose is one having the composition below, in which case the adhesive can be satisfactorily fixed upon the spindle by oven drying at 160° F. for two hours although other temperatures and periods of drying can be employed with satisfactory results. The aforesaid adhesive is comprised as follows:

	Parts by weight
Liquid phenol aldehyde resin condensation product ("Bakelite" BC–5763)	75
Clay	25
Furfural thinner	7

The previously compacted ring-shaped segments composed of abrasive-included sheet material **3** which are to form that part of the abrasive body **13** below the end **14** of the spindle **10** and surrounding the spindle, before being assembled in the mold set-up, are given a light sizing coating of adhesive or cement in the spindle-receiving part. A cement of the same composition as that used to size the spindle is employed, after which the sized segments are preferably air dried. A sufficient but limited amount of adhesive is used to provide a small degree of penetration about the arbor area of the ring-shaped segments, producing an adhesive-impregnated zone **15** in the spindle-receiving part of the segments. One or more of the pre-pressed segments are used to form the spindle-receiving portion of the abrading body depending upon the relative thickness of the individual segments and the thickness of that part of the abrasive article. After positioning the adhesively treated ring-shaped segments about the spindle, a sufficient number of segments composed of disc-shaped sheet material **5** are likewise superimposed on the ring-shaped segments and spindle to provide the desired thickness of the complete article after compacting. It has been found desirable usually to wet the surfaces of the segments to be joined in making up the article with a small amount of solvent for the adhesive in order to unite the several segments more strongly in the final article. After assembling the various elements of the abrasive article as hereinabove described, the assembly of parts is compacted, as for example, by subjecting a mounted point of 1 inch thickness to a pressure of 2000 pounds per square inch at 260° F. for 30 minutes. The temperature, pres-

sure and period of pressing varies and depends upon the size of the specific article being made. The shaped and mounted article is then removed from the mold and placed in an oven for 5 hours at 260° F. to complete the curing of the adhesive. The article is then dressed and edged according to usual procedures after which it is ready for use.

While the specific procedure described above has been found to be the most efficient and desirable way of providing the abrasive body with a reentrant or spindle-receiving part by the use of ring-shaped sheet material or ring-shaped segments in accordance with the herein described process, that part of the body can be provided by other means without departing from the spirit of the invention. For example, the entire abrasive body can be formed by initially forming the body from a plurality of disc-shaped abrasive sheets after which the re-entrant or spindle-receiving part is obtained by drilling or otherwise cutting out a portion for reception of the spindle, the balance of the process being substantially the same.

Figure 2 shows a finished abrasive tool or point as made in the mold set-up of Figure 1 and consists of a compacted abrasive-containing, felted fibrous abrading body 13 formed from a plurality of ring-shaped sheets 3 and disc-shaped sheets 5 of abrasive-included sheet material, and mounted and secured on the steel spindle 10. The adhesive-impregnated area 15 about the spindle 10 is also shown.

It has been found that the character of the abrasive articles produced by the herein described process, as for example the grade of hardness, can be altered by variations in the quantity and character of the adhesive binder employed in making the abrasive-containing, fibrous sheet material, and also by the choice of auxiliary or supplemental adhesive substance which is applied to the sheet material as a size. It is desirable that the adhesives selected for making the aforesaid articles do not smear during grinding operations. This is especially true in polishing wheels and devices where smearing of the bond tends to produce a "hot cutting" or burning action which is ruinous to the finish being produced.

Among those substances which can be satisfactorily used as bonding materials herein in addition to the specific adhesive sizing composition set forth above, and which are non-smearing, are included glue adhesives, particularly when treated with plasticizing agents such as ethylene glycol, sorbitol, glycerine and the like. The plasticizer may amount to as much as 40% by weight of the total adhesive binder. Other non-smearing adhesives which can be used are casein glues, natural or synthetic rubber latices, urea resins, phenol-aldehyde resins and other natural or synthetic resins, or mixtures of two or more of such adhesives.

The herein described invention offers numerous improvements and advantages over the prior art. It provides a practical method of fabricating small-sized abrasive articles of the mounted type such as grinding and polishing points, tools and the like, having a "soft" or resilient combined cutting and polishing action, and in which the abrading body is strongly and securely mounted upon the mounting spindle or shaft.

The articles of the present invention have a relatively high rate of stock removal and at the same time produce a surface finish equal to that obtained by an ordinary bonded abrasive article embodying abrasive particles several grit sizes smaller. Mounted abrasive products made as herein described cut both efficiently and effectively, with an accompanying polishing action, and are capable of high operating speeds without chattering, operating smoothly to remove burrs and produce very high finishes on metal castings at surface speeds of 9500 feet per minute. It is theorized that the "soft" cutting action of such abrasive articles is the result of the abrasive grains being cushioned by the surrounding felted fibers and binder so as to prevent gouging and scratching and to provide the abrasive grains with a yielding background by which they are caused to maintain individually more effective contact with the work and at the same time absorb and take up inequalities of surface so as not to scratch or mar the surface being finished.

Although I have set forth, in the specific example, certain specific conditions, it will be understood that my invention is not limited to the conditions there described. Generally speaking, I have found it to be desirable to mold the articles under pressures of the order of 1000–2000 pounds per square inch. The length of time that the article is subjected to heat and pressure is determined to some extent by the size of the article being molded but is usually in the range of 15–30 minutes. Likewise, articles of different grades can be made by varying the fiber, abrasive and adhesive content of the abrasive-containing felted fibrous material, the amount and kind of adhesive applied thereto as a size, and by the density to which the articles are compacted. In general the sheet material contains 5–20% adhesive, 5–20% fibers, usually cotton, and 65–90% abrasive. The densities of the articles where the abrasive material is fused alumina are usually within the range of 0.066–0.093 pound per cubic inch.

Having described and set forth the invention in detail, the scope of the invention is not to be confined other than by the appended claims.

I claim:

1. The method of making abrasive articles of manufacture which comprises forming an abrasive body having a re-entrant part adapted for reception of a mounting spindle by assembling a plurality of layers of felted fibrous, abrasive-containing sheet material of the desired size and shape in superimposed relation, compressing said assembly of sheet material to roughly form the desired abrasive body, applying a coating of adhesive to the re-entrant surfaces so provided in said abrasive body and drying the adhesive to limit penetration of the adhesive into the abrasive body, roughening the surface of the spindle to be inserted into the said abrasive body, coating said roughened surface with an adhesive and drying, inserting the spindle into the re-entrant part of the abrasive body, and subjecting the assembly to heat and pressure to firmly secure the spindle to the abrasive body and form the abrasive shape.

2. The method of making abrasive articles of manufacture which comprises forming an abrasive body by assembling a plurality of layers of previously sized, felted fibrous, abrasive-containing sheet material of the desired size and shape in superimposed relation, compressing said assembly of sheet material to roughly form the desired abrasive body, providing in said abrasive body a re-entrant part adapted for the reception of the mounting spindle, impregnating the spindle receiving portion of the abrasive body with a phenolic adhesive cement and drying the same,

roughening the surface of the spindle to be inserted into the said abrasive body, coating said roughened surface with an adhesive and drying, inserting the spindle into the re-entrant part of the abrasive body, and subjecting the assembly to heat and pressure to firmly secure the spindle to the abrasive body and form the abrasive shape.

3. The method of making abrasive articles of manufacture which comprises forming an abrasive body by assembling a plurality of layers of previously sized felted fibrous, abrasive-containing sheet material of the desired size and shape in superimposed relation, compressing said assembly of sheet material to roughly form the desired abrasive body, providing in said abrasive body a reentrant part adapted for the reception of the mounting spindle, impregnating the spindle receiving portion of the abrasive body with a phenolic adhesive cement and a filler and drying the same, roughening the surface of the spindle to be inserted into the said abrasive body, coating said roughened surface with an adhesive and drying, inserting the spindle into the re-entrant part of the abrasive body, and subjecting the assembly to heat and pressure to firmly secure the spindle to the abrasive body and form the abr sive shape.

4. The method of making abrasive articles of manufacture from a plurality of layers of felted fibrous abrasive containing sheet material which comprises cutting a number of blanks of the desired size and shape from said sheet material, applying a coating of adhesive to the surface of said blanks, assembling a plurality of said adhesively coated blanks in superimposed relation, compressing said assembly of sheet material to roughly form the desired abrasive body, providing in said abrasive body a re-entrant part adapted for the reception of the mounting spindle, applying a coating of adhesive to the re-entrant surfaces so provided in said abrasive body and drying the adhesive to limit penetration of the adhesive into the abrasive body, roughening the surface of the spindle to be inserted into the said abrasive body, coating said roughened surface with an adhesive and drying, inserting the spindle into the re-entrant part of the abrasive body, and subjecting the assembly to heat and pressure to firmly secure the spindle to the abrasive body and form the abrasive shape.

5. The method of making abrasive articles of manufacture which comprises forming an abrasive body by assembling a plurality of layers of previously sized felted fibrous, abrasive-containing sheet material of the desired size and shape in superimposed relation, compressing said assembly of sheet material to roughly form the desired abrasive body, providing in said abrasive body a re-entrant part adapted for the reception of the mounting spindle, applying a coating of adhesive to the re-entrant surfaces so provided in said abrasive body and drying the adhesive to limit penetration of the adhesive into the abrasive body, roughening the surface of the spindle to be inserted into the said abrasive body, coating said roughened surface with an adhesive and drying, inserting the spindle into the re-entrant part of the abrasive body, and subjecting the assembly to heat and pressure to firmly secure the spindle to the abrasive body and form the abrasive shape.

FREDERICK A. UPPER.

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