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F. A. UPPER

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METHOD OF MAKING ABRASIVE ARTICLES

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Fig. 1.

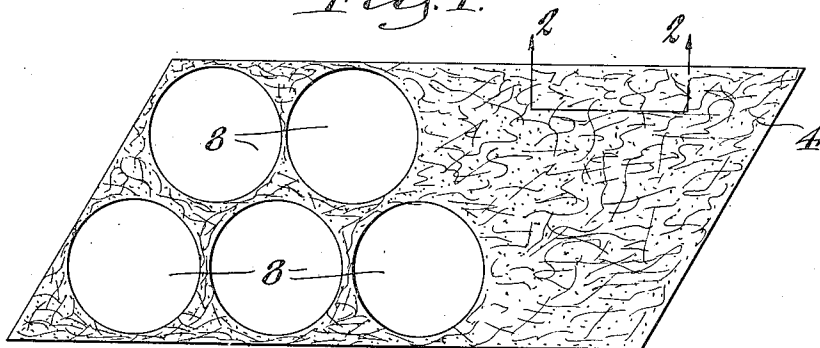


Fig. 2.

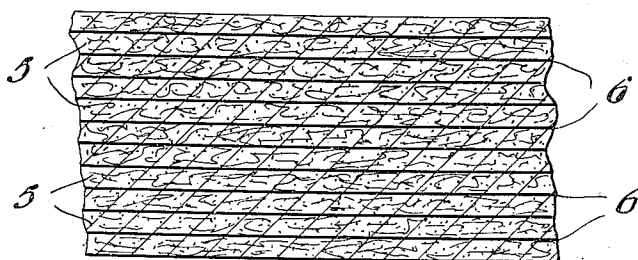
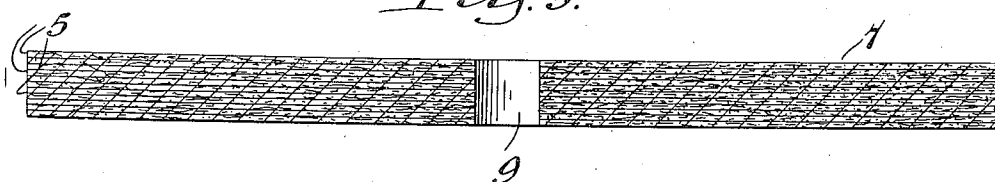


Fig. 3.



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METHOD OF MAKING ABRASIVE ARTICLES

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Application June 27, 1944, Serial No. 542,324

8 Claims. (Cl. 51—297)

This invention relates to the manufacture of abrasive articles. More particularly it relates to methods of making resilient abrasive articles of the bonded type such as grinding and polishing wheels, discs, blocks, pads, sticks and other shapes having a mild or "soft" abrading action and formed of a composite of felted fibrous sheets having abrasive grain, and usually an adhesive binder therefor, included internally of the fibrous sheets. The invention especially pertains to improved methods of making such abrasive articles from a plurality of superimposed flexible, fibrous abrasive-containing sheets or web material whereby the finished article is more facily and quickly formed and in which the resultant product is characterized by a more uniform density and hardness grade throughout together with a mild or "soft" abrasive action which combines an effective cutting rate with an efficient and satisfactory polishing action.

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 having a combined cutting and polishing action have been made

from a plurality of felted fibrous abrasive containing sheets superimposed one on the other and adhesively or otherwise secured in position for grinding and polishing use. Such articles and methods of making them have been set forth and described in United States Patent No. 2,355,667, issued August 15, 1944. According to the procedure described therein abrasive wheels and other shapes are formed by cutting pieces of the abrasive-containing fibrous material of the size and shape of the desired article from the roll of abrasive-included web material and assembling them directly to form the desired article. While the resultant articles have shown a cutting action of the desired type, the methods of making them have been fraught with numerous procedural difficulties which make it extremely difficult to carry out the operation efficiently and effectively, especially on a large or commercial scale, to produce articles of uniform characteristics not only throughout each individual article but also to provide large numbers of articles having uniformity of abrading characteristics from article to article. The making of smaller wheels and shapes has presented specific additional problems involved in the handling of large numbers of small pieces of the loose sheet material.

I have discovered improved methods of making the aforesaid articles whereby the above mentioned and other difficulties are obviated and by which large numbers of abrasive wheels and other shapes can be efficiently and quickly fabricated regardless of size and shape and which will be not only uniform throughout each individual article but in which such uniformity in cutting characteristics can be repeatedly obtained and controlled in large numbers of articles in accordance with the results desired. The herein described methods, by reason of the increased rate of production made possible and the improved uniformity of product obtained thereby, results in economic savings as well as the accrual of other advantages all of which will become apparent as the description proceeds.

In accordance with the present invention improved abrasive articles of the resilient or "soft" acting type are made by a process in which the abrasive included, felted, fibrous sheet material is first assembled in superimposed relation in the form of large sheets of the material and subjected to an initial or preliminary compressing operation to provide large slabs of a specified thickness, as for example $\frac{1}{4}$ " thick when compressed. The number of individual sheets to be

used in forming one of the compressed slabs is preferably determined by weighing. These slabs can be further processed immediately or stored indefinitely for later processing. 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 initial consolidation into slabs, whether in its original roll form or after it has been cut into large sheets for forming the compressed slab stock.

The above compressed slab stock is then died out on a punch press or by similar mechanism, or cut or punched out by hand, to provide a number of smaller rings, discs or other shaped pieces, the shape depending upon the specific article to be made therefrom. One or more of the smaller pieces is then subjected to a further consolidating operation as, for example, by molding under heat and pressure to mature or set the adhesive binder and form the desired abrasive article. After a final dressing or edging operation in accordance with customary practice the article is ready for use.

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

Figure 1 is a top plan view of a single compressed slab composed of a number of sheets of superimposed, felted, fibrous abrasive-containing web material made in accordance with the first step of the present process and shows the manner in which smaller shapes are died or cut from the slab.

Figure 2 is an enlarged fragmentary, vertical cross-section through the line II—II of Figure 1, and

Figure 3 is a diagrammatical, vertical cross-section through an abrasive wheel 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. 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 the abrasive included sheet material by said wet-felting procedure is that set forth and fully described in co-pending application Serial No. 461,139, filed October 7, 1942.

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 abrasive included paper stock web material is that set forth and fully described in co-pending application Serial No. 461,140, filed October 7, 1942.

In accordance with the process therein set forth, fibrous paper-stock abrasive sheet material is made from an aqueous suspension of around 3% fiber content in which the fibers are distributed in the suspension as substantially individu-

ally separated fibers. This fibrous suspension is agitated, beaten, or otherwise mechanically treated, with sufficient vigor to render the fibers partially gelatinous, abrasive grain being 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 softenable 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 on 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 suspension, 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.

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 abrasive articles in accordance with the present invention. As a specific example of the manner in which the present proc-

ess has been carried out and an abrasive article made in accordance with 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 is sized with a 20% aqueous solution of a casein glue (such as that made and sold under the trade-mark name of "Casco" by Casein Corporation of America) to provide about 10% casein by weight based on the fibrous sheet material. The roll of adhesively sized abrasive included fibrous sheet material is cut into the form of large individual sheets as, for example, in the shape of the parallelogram-shaped slab shown in Figure 1, a slab size convenient for handling being approximately 28" long by 13" wide. It has been found that in the use of the slabs in the making of disc-shaped articles such as grinding wheels and polishing wheels and the like that if the acute inner angle of the parallelogram is 60° there is a minimum of wasteage entailed in cutting the material for use. Although the fibrous abrasive web is preferably sized with adhesive on one or both sides in roll form due to the convenience of handling, it can, if desired, be sized after it has been cut into individual sheets; also the process is not restricted to the specific size or shape of sheet set forth as other sizes and shapes can be employed to suit the particular conditions and equipment available and the type and size of abrasive article to be made. A sufficient number of the adhesively coated sheets are assembled in superimposed position to provide a slab of specified thickness as, for example, 1/4" 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 forming the slab 4 illustrated in Figures 1 and 2 a number of abrasive included felted fibrous sheets 5, which have been previously sized on one side with an adhesive coating 6 consisting of a 20% aqueous solution of casein glue to the extent of about 10% casein by weight of the fibrous sheet material, are assembled in superimposed relation and cold pressed at a pressure of 4000 pounds per square inch. The pressing operation is usually carried out on a number of slabs simultaneously by the use of either a multiple platen press or by the insertion of steel plates between the various groups of sheet material forming the slabs. The pressures employed are adequate to force the sheet material together so firmly that the resulting slab can be conveniently handled as a single piece although the sheets are not strongly bonded together nor is the adhesive usually permanently set or cured at this point in the process. It has been found satisfactory in sizing the sheet material to apply the adhesive solution to only one side of the sheet material, although if desired the adhesive can be applied to both faces; also, in assembling the sheet material when the adhesive is applied to only one side of the sheet material the different sheets are preferably arranged either with the adhesively coated sides facing inwardly toward the center of the assembly or with the adhesively coated sides all facing in one direction. The slab fragment depicted in Figure 2 in enlarged form shows the former arrangement. The thickness of each slab is controlled and held to a predetermined figure

by means of stop blocks inserted between the press platens.

Referring further to the drawing, Figure 3 shows a cross-sectional view through an abrasive wheel 7 formed from a single disc-shaped segment of the slab material such as that shown in Figures 1 and 2. The initially compressed slab of Figure 1 shows a number of disc shaped segments 8 removed from the slab for the fabrication of abrasive wheels. A single disc-shaped segment 8 cut from the slab 4 shown in Figure 1 and consisting of a number of layers of abrasive-included, adhesively-coated felted fibrous sheet material 5 is placed in a hot press and subjected to a pressure of 1700 pounds per square inch and a temperature of 260° F. for 15 minutes. The hot pressed wheel is then removed from the press and cooled after which the central arbor hole 9 is punched out on a punch press and the wheel placed in an oven for 5 hours at 260° F. to complete the curing of the bond. The temperature, pressure and period of pressing is varied depending upon the size and shape of the specific article being made. The article, after the oven cure, is dressed and edged according to the usual procedure. When only a single, disc-shaped segment is used, the resulting abrasive wheel is usually one of approximately 1/4" thickness. Thicker wheels are formed by superimposing one or more additional disc shaped segments upon the first segment and hot pressing the several discs of slab material to combine the several discs and compress the material to the desired density. In forming abrasive wheels and like articles having central arbor holes in which the article has a final thickness greater than approximately 1/4", it has been found preferable to die out the arbor hole prior to the hot pressing operation.

Although the customary hot pressing procedures are acceptable in carrying out the present process, improved methods of performing the hot pressing operation have been devised for the making of bonded abrasive articles of the type herein described. These improved methods are more fully set forth and described in co-pending application Serial No. 542,567 filed June 28, 1944. They are applicable to carrying out the present invention and, in fact, they constitute the preferred method of obtaining the final consolidation and formation of the abrasive article. Briefly, the piece or pieces of slab material from which the grinding wheel or other abrasive shape is to be formed are placed between two layers of heavy cloth which have been previously saturated with water and the excess water removed as by squeezing between a pair of rubber rolls. A suitable fabric is heavy, close-woven canvas or duck although other woven or felted fabric materials suitably dampened can be used. By the use of these cloth layers inserted between the hot press platens and the top and bottom faces of the slab material a more uniform abrasive body is obtained as is more fully explained in the aforementioned co-pending application. Abrasive articles made by this latter method, following the hot pressing operation, are likewise subjected to an oven cure similar to that described above.

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 mate-

rial, and also by the choice of auxiliary or supplemental adhesive substance which is admixed with the sheet material as a size thereto. It is desirable that the adhesives selected for making the 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 abrasive articles such as grinding and polishing wheels, stones and the like, having a "soft" or resilient combined cutting and polishing action.

The articles of the present invention have a relatively high rate of stock removal from the material being ground 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. Abrasive products made as herein described cut both efficiently and effectively, with an accompanying polishing action, and are capable of being used at high operating speeds without chattering, operating smoothly to remove burrs and produce very high finishes on metal castings. 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 to 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. The length of time that the article is subjected to heat and pressure is determined to some extent by the thickness of the article being molded, but is usually in the range of 15 to 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.

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 bonded abrasive articles from a plurality of superimposed layers of abrasive-included, felted, fibrous sheet material which comprises assembling a number of sheets

of previously sized abrasive-included fibrous web material in superimposed relation, subjecting said assembled sheets to an initial consolidating action to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slabs, and further consolidating said cut out pieces of compressed slab material to form abrasive articles of the desired thickness.

2. The method of making bonded abrasive articles from a plurality of superimposed layers of abrasive-included, felted, fibrous sheet material which comprises assembling a number of sheets of previously sized abrasive-included, fibrous web material in superimposed relation, subjecting said assembled sheets to an initial consolidating action to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slabs, and further consolidating said cut out pieces of compressed slab material by means of heat and pressure to form abrasive articles of the desired thickness.

3. The method of making bonded abrasive articles from a plurality of superimposed layers of abrasive-included, felted, fibrous sheet material which comprises applying an adhesive coating to a surface of an abrasive-included, fibrous web material in roll form and drying the same, cutting large sheets from the adhesively-coated web material, assembling a number of the sized sheets of abrasive-included, fibrous web material in superimposed relation, subjecting said assembled sheets to an initial consolidating action to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slabs, and further consolidating said cut out pieces of compressed slab material to form abrasive articles of the desired thickness.

4. The method of making bonded abrasive articles from a plurality of superimposed layers of abrasive-included felted, fibrous sheet material which comprises cutting a number of large sheets from the abrasive included fibrous, web material, applying an adhesive coating to a surface of said sheets, assembling a number of the adhesively-coated sheets of the abrasive-included, fibrous web material in superimposed relation and then subjecting said assembled sheets to an initial consolidating action to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slabs, and further consolidating said cut out pieces of compressed slab material to form abrasive articles of the desired thickness.

5. The method of making bonded abrasive articles from a plurality of superimposed layers of abrasive-included, felted, fibrous sheet material which comprises assembling a number of sheets of previously sized abrasive-included; fibrous web material in superimposed relation, cold pressing said assembled sheets to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slabs, and further consolidating said cut out pieces of compressed slab material by means of heat and pressure to form abrasive articles of the desired thickness.

6. The method of making bonded abrasive articles from a plurality of superimposed layers of abrasive-included, felted fibrous sheet material which comprises assembling a number of sheets of previously sized abrasive-included, fibrous web material in superimposed relation, cold pressing

said assembled sheets at an approximate pressure of 4000 lbs. per square inch to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slab material, and consolidating said pieces by means of heat and pressure to form abrasive articles of the desired thickness.

7. The method of making bonded abrasive articles from a plurality of superimposed layers of abrasive-included, felted, fibrous sheet material which comprises assembling a number of sheets of previously sized abrasive-included, fibrous web material in superimposed relation, cold pressing said assembled sheets to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slabs, and hot pressing the cut out pieces of the compressed slab material to form abrasive articles of the desired thickness.

8. The method of making bonded abrasive articles from a plurality of superimposed layers of abrasive-included, felted, fibrous sheet material which comprises assembling a number of sheets of previously sized abrasive-included, fibrous web material in superimposed relation, subjecting said assembled sheets to an initial consolidating action to form therefrom a compressed slab of the desired thickness, cutting out pieces of the desired size and shape from the said compressed slab, assembling in superimposed relation a sufficient number of the cut out pieces of initially compressed slab material to provide an abrasive article of the desired thickness when permanently compacted, and further consolidating the superimposed pieces of compressed slab material by means of heat and pressure to form the desired abrasive article.

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