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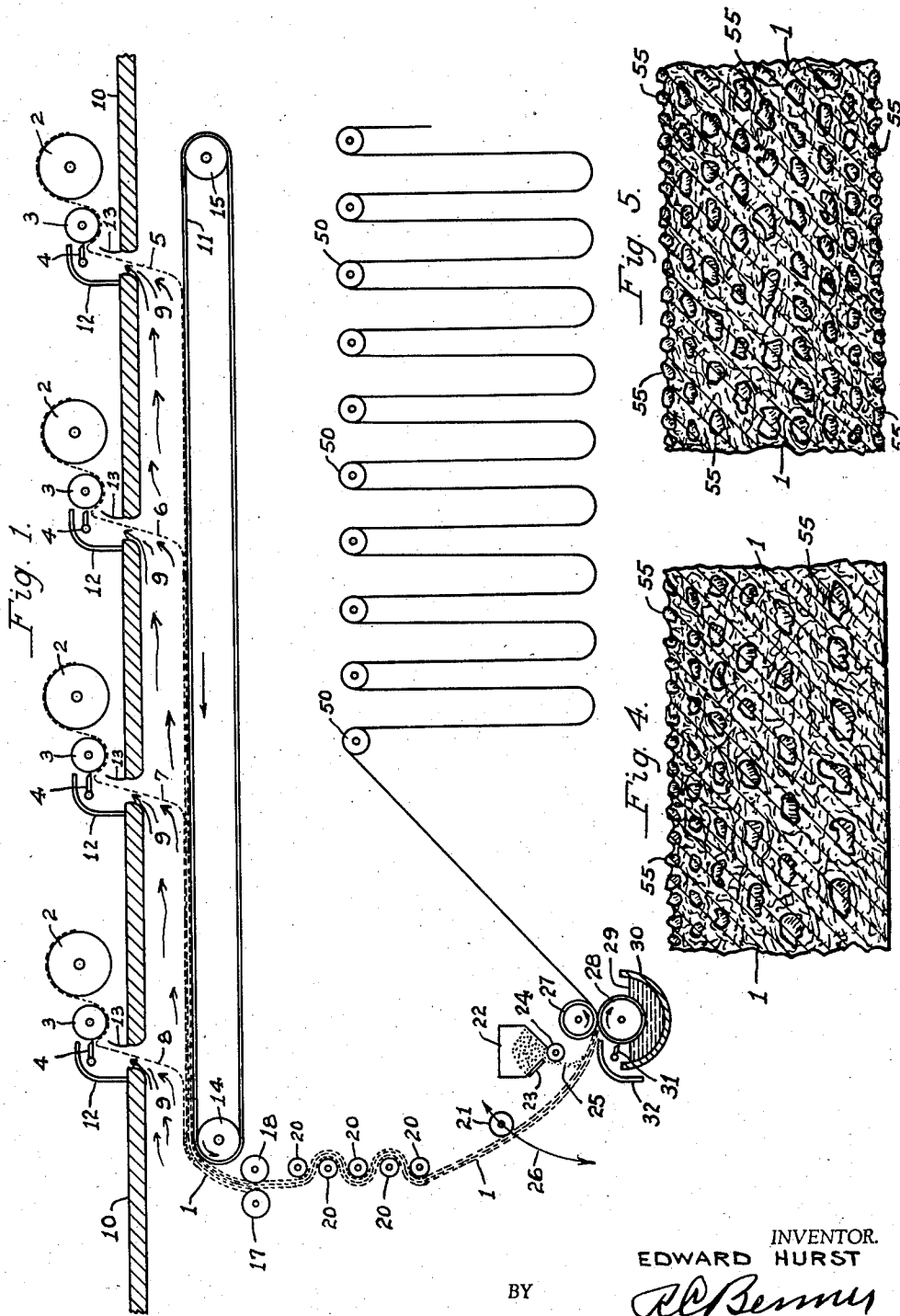
E. HURST

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METHOD AND APPARATUS FOR MANUFACTURING ABRASIVE MATERIALS

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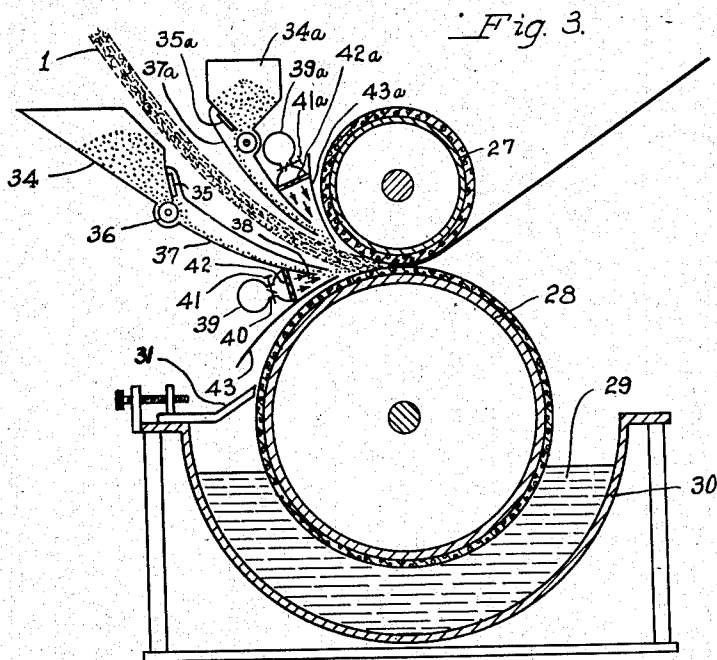
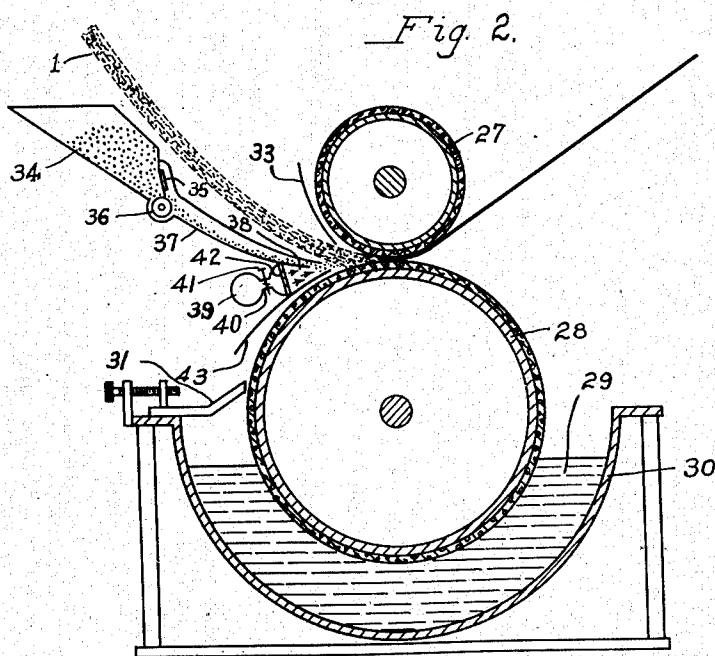
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METHOD AND APPARATUS FOR MANUFACTURING ABRASIVE MATERIALS

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12 Claims. (Cl. 51—297)

This invention relates to webs of abrasive material and to methods and apparatus for manufacture thereof. More particularly, the present invention is concerned with the manufacture of abrasive materials in which the fibers of a plurality of carded fibrous membranes are formed together by definite interengagement or interweaving to form a substantially non-lamellar web structure and abrasive grain included internally of the web and/or extending in part above the surface thereof. This invention is concerned further with the manner of introducing or including the abrasive material and an adhesive binder agent into the web so that the abrasive particles are anchored in the interstices of the fibers and the gussets made by the fiber intersections and further cemented in place by the adhesive.

Heretofore in the manufacture of flexible abrasive materials, such as sandpaper, and the like, the practice has been to apply a layer of adhesive to a paper or cloth backing member, apply a layer of abrasive thereover and then apply an additional sizing layer of adhesive to more firmly anchor the abrasive particles in position. The present invention should not be confused with the coated abrasives of the prior art, since it differs therefrom by the absence of the conventional backing member. It represents an improvement over such articles by reason of the elimination of the backing and the distinct line of demarcation which has existed heretofore between the backing member and the coating of abrasive granules. In addition, its fibrous structure lends a strength, controllable flexibility and durability to the final product which meets the requirements for abrasive paper, as well as many applications for which the conventional abrasive paper is not suited.

Methods have been proposed for the incorporation of abrasive grain into a paper base by mixing abrasive grains into a macerated, watery mass of paper pulp and then forming abrasive articles from the mixture. Such methods have been unsatisfactory because of the fact that a solid, densely matted body was formed which entirely masked the cutting edges of the abrasive particles, and also the absence of clearance spaces prevented the formation of chips.

I have found that the above difficulties can be overcome and flexible abrasive web materials produced with a substantial saving in time and operations by forming a web of a plurality of carded fibrous membranes, forming said membranes together by definite interweaving to form

a strong non-lamellar web structure and applying abrasive granular material internally of said fibrous web, said abrasive particles extending from the interior to the surface and projecting therefrom. A suitable adhesive agent is also incorporated within said web and the treated fibrous web is consolidated to a desired density. The present invention further provides a method and suitable apparatus with which the abrasive grain and the adhesive binder may be applied to the web and caused to penetrate and permeate throughout the fibrous web structure. The abrasive particles enter into the interstices of the individual fibers and between the fibers of the web, and when the web is consolidated, the individual fibers are pressed down and around the base of each individual abrasive particle to increase the anchorage thereof. This also causes the cutting edges of the uppermost grains to project above the surface of the web and a sharp abrading surface is produced. Furthermore, the abrading action is not confined to a superimposed layer of abrasive grains on the upper surface of the web, but the abrasive properties extend substantially all the way through said web, there being no distinct line of demarcation between the fibrous web and the abrading surface.

Abrasive grain can be introduced entirely or partially within the fibrous web structure in amount and character to suit the conditions and nature of the intended use. For example, the abrasive grain may be applied in such a manner that there is a maximum amount of abrasive particles at one surface of the web, with the amount of grain progressively diminishing as the distance from that surface of the web becomes greater, there being little or no abrasive grain at the opposing surface of the web. However, if desired, the abrasive may be applied into both surfaces of the web and an article produced in which the quantity of grain diminishes equally from both surfaces of the web toward the interior. A coating of abrasive grain may also be applied, if desired, and adhesively secured to the top surface of the web. A sizing layer of adhesive may be applied to the surface coating of abrasive material or to the surface of the abrasive-included web.

Various modifying agents, such as waterproofing compounds, anti-friction agents, embrittling materials, flexibilizers and other fillers, may be incorporated in the web during manufacture in order to render the web resistant to water or impart specific properties thereto.

In order that the invention may be more clearly set forth and made more understandable, reference is made to the accompanying drawings, in which

Figure 1 is a diagrammatic side elevation of one form of apparatus for making abrasive webs in accordance with the present invention;

Figure 2 is an enlarged view of a portion of the apparatus of Figure 1, and shows the adhesive-applying means in greater detail, as well as modified means for applying the abrasive grain into and through the web;

Figure 3 is a modification of the apparatus shown in Figure 2;

Figure 4 is a greatly enlarged vertical-section through a fragment of an abrasive web made according to the present invention; and

Figure 5 is a similarly enlarged vertical-section of a modified form of web made in accordance with the present invention.

Figure 1 of the drawings illustrates one form of apparatus which may be employed in the production of fibrous abrasive materials by the concurrent manufacture of a fibrous web material and the inclusion of abrasive grains and adhesive binder therein. The particular apparatus shown includes a plurality of card assemblies suitably spaced apart and consisting of card cylinders 2, doffer cylinders 3 and combs 4 adapted to form and deliver a number of carded membranes 5, 6, 7 and 8 to the moving conveyor 11. The carded membranes are uniform webs of loosely adhering independent fibers and may consist of any animal, vegetable, mineral or synthetic fibrous material capable of being carded into web form. Such materials include natural fibers, such as cotton, wool, jute, flax and the like, or any of the newer synthetic fibers, such as glass wool, resinous or synthetic rubber-like fibrous materials. Any one of these fibrous materials may be used singly or two or more may be mixed in any desired proportion. Cotton fibers have been found to be highly satisfactory in the present process and consequently will be used as a specific example in connection with the detailed description of the apparatus and the method of manufacture.

The carding machines are well known in the textile art and no detailed description is deemed necessary. Although only four cards are shown in the drawings, any number of cards may be used, depending upon the desired weight or thickness and type of fibrous web being manufactured. The cards are arranged so that their longitudinal axes are parallel but offset slightly from each other, laterally of the carrier belt 11.

The carded membranes are delivered from the cards as light, uniform webs and fed by gravity through orifices 9 in the floor 10 onto a moving carrier belt 11, which is slightly undulated by suitable means not shown. This carrier belt is slightly wider than the width of the deposited membranes and may have cooperating flanges for guiding the oncoming membranes onto the traveling support. As the membranes pass through the orifices of the floor, they are shielded from any undesirable external influences, such as strong air currents, by protecting side walls or plates 12 and 13. The carrier belt 11 is supported at the opposite ends thereof by the rolls 14 and 15, which are driven by suitable driving means, not shown. The speed of the belt is synchronized with the rate of feed of the membranes in order to prevent any pull on the membranes during their deposition.

As the fibrous membranes pass down through

the orifices 9 and are deposited onto the moving support, a gentle controlled current of air or other gas indicated by the arrows is caused to flow against the movement of the membranes and upwardly through the respective orifices 9. Since the fibers of the membranes are very light in character, this gentle current of air causes a displacement and up-ending of the individual fibers in each membrane as it passes through the respective orifice. Thus the ends of the individual fibers are shifted from their normal longitudinal arrangement, which was assumed as a result of the carding operation, and caused to extend in a number of different directions, generally non-parallel. This displacement of the fibers is generally normal to the surface of the membranes and, as two or more membranes are brought together, the up-ended fibers of each membrane readily blend together by definite interengagement or interweaving in a multiplicity of planes. This action is called aerodynamic weaving.

The interlocked web is then passed between the rolls 17, 18 and back and forth between the series of rolls 20, which are arranged at successively lower levels. These rolls do not exert any appreciable pressure on the web and are preferably all driven at the same peripheral speed as the moving web in order to avoid any tension on the web. The back and forth or alternate bending of the web by the rolls 20 serves to alternately lengthen and contract opposite sides of the web, and this action further aids in interlocking together the fibers of the successively applied membranes. The result of the various steps is a firm, homogeneous interlocking structure which is non-lamellar in final appearance and with the individual fibers extending in a multiplicity of different directions and disposed in a multiplicity of different planes.

The web 1 is still light and uncompacted as it leaves the rolls 20 and passes down around the adjustable roll 21 to a zone where the abrasive grains are applied to the web and included internally thereof. The abrasive particles pass from the hopper 22 through an adjustable feed gate 23 and over a distributing roll 24 and are deposited by gravity on and into the open structure of the web 1. The extent of penetration of the abrasive granules into the web may be varied to any desired extent by changing the angle of the moving web with respect to the falling stream of grain 25. This is readily accomplished by moving the position of the adjustable roll 21 along the path indicated by the curved arrow 26. By such adjustment, the web may be moved horizontally and at an angle of 90 degrees with respect to the falling stream of grain, or at an oblique angle with respect thereto. The greatest depth of penetration of the grain into the web structure will be obtained when the web is moved horizontally and a lesser degree of penetration obtained as the angle between the web and falling stream of grain is decreased. The abrasive particles readily penetrate into the interstices of the web and the fibers, due to its open, unconsolidated structure, and with appreciable improvement to the interlocking non-lamellar properties of the fibrous web.

The abrasive-included web is then passed between the rolls 27 and 28, where it is consolidated to a desired density and an adhesive binder applied in sufficient amount to cement the web. The adhesive roll 28 revolves in a liquid adhesive 29 contained in the pan 30, and upon each revolution, transfers a desired uniform quantity of adhesive into the web. The quantity of adhesive

is regulated by the adjustable scraper bar 31, which limits the thickness of the adhesive layer carried by the roll 28. These two rolls are preferably driven at substantially the same speed as the web passing therebetween and are provided with a surface covering of resilient adsorption material.

An adjustable baffle or shield 32 is provided to cover the front portion of the adhesive pan 30 and prevent any grain from falling through the web and into the adhesive.

After leaving the adhesive-applying device, the consolidated fibrous abrasive web is passed to a suitable drying or curing chamber, where it is supported by any suitable means, such as by the rolls 50, until the adhesive binder is fully set or matured. The web is then removed from the drying rack and given any additional treatment, which may be required, and finally cut up into sheets, belts, discs and other abrasive articles of proper sizes and shapes as required for sale.

Figure 2 of the drawings illustrates an improved form of apparatus in which an air stream is used to project the abrasive grains into the interstices of the fibrous web where they become securely entrapped and the air is completely dissipated after being completely filtered of all abrasive particles. Necessarily the air floated abrasive particles are controlled both as to velocity and direction and no distortion of the web occurs. The adhesive applying rolls illustrated in Figure 1 are also shown in somewhat greater detail. In this apparatus the preformed web 1 is passed from the rolls 20 of Figure 1 directly to an abrasive applying zone. The abrasive grain is fed from a grain hopper 34, through an adjustable feed gate 35, over a revolving feed roll 36 and through an inclined chamber 37 into a stream of air issuing from the air nozzle generally indicated by the reference numeral 38. This stream of air, indicated by the arrows, projects the abrasive particles into the fibrous web and as the air stream flows therethrough the abrasive material is filtered out of the air stream and deposited within the interstices of the web. The air stream continues on through the open structure web and is dissipated through the space between the shield member 33 and the upper roll 27.

The air nozzle 38 comprises an inlet primary air supply duct 39, a distributing duct 40, regulating means 41 and a distributor orifice 42 for equalizing the air flow within the nozzle. The plate shield 43 and the outlet end of the grain feed chamber 37 are adapted to form a suitable nozzle for directing the abrasive laden air stream into the fibrous web. The zone of inclusion or point where the air stream strikes the web is just forward of the nip of the rolls 27, 28. Thus as the grain enters the open fibrous web a liquid adhesive binder 29 is applied sequentially therethrough and the web is consolidated by the rolls 27, 28. The web containing included abrasive and an adhesive binder is then passed upwardly from the roll 27 to the drying rack 50 shown in Figure 1.

The apparatus of Figure 3 is similar to that illustrated by Figure 2 and described in connection therewith. In Figure 3, however, I have provided an additional grain feed and including unit in order that granular or powdered materials may be simultaneously applied into the web from both surfaces. With this arrangement abrasive particles can be applied into both surfaces of the web or if desired an abrasive material may be applied from one feed unit and a modifying agent, or antifriction ingredient, such as talc, soapstone,

graphite, and the like, can be applied to the opposite side of the web by the second unit. The subscript *a* placed after various of the numbered parts of Figure 3 represents parts of the mechanism which are substantially the same as or duplicates of those parts which are similarly numbered without the subscript *a*.

The depth of penetration of the abrasive and other powdered materials, applied by the apparatus shown in Figures 2 and 3, can be readily adjusted to any desired degree by directional control of the air, and pressure control in the nozzle. Thus the material may be applied internally of the web in such a manner that there is a maximum amount of material at opposite surfaces of the web and progressively decreasing toward the center of the web. Or by proper adjustment of the air pressure and grain feed the abrasive material can be deposited substantially uniformly throughout the web.

In a modified form of the present process, I may apply an additional surface layer of abrasive grains to the surface of the included abrasive web. In carrying out this additional step of the process, an additional layer of adhesive may be applied to the surface of the consolidated web by any conventional adhesive applying means, such as the adhesive roll 28, coating pressure roll 27 and pan 30 of Figure 1 of the drawings. A layer of abrasive grains may be applied to the adhesive coating by gravitational means, in which a given quantity of grain is uniformly distributed from a suitable grain hopper similar to 22 and permitted to fall thereon. Or, if desired, any of the more recently developed electrical and mechanical methods of grain deposition and orientation may be utilized. For a more detailed description of suitable electrostatic apparatus for orientation and projection of the abrasive granules onto an adhesively coated web, reference is made to Patent No. 2,187,624, issued January 14, 1940, to Romie L. Melton, Raymond C. Benner and Henry P. Kirchner. Suitable mechanical apparatus for the orientation and deposition of abrasive grains is described in Patent No. 2,141,658, issued December 27, 1938. This surface coating of abrasive grain may be applied at any time before or after partial or complete drying or curing of the included abrasive web. The conventional sizing coating of adhesive may be applied over the deposited layer of abrasive grains. In certain instances it is desirable to apply a sizing coating of adhesive or filler to one or both surfaces of the fibrous web to impart specific properties thereto. Any of the abrasive material in common use may be employed in practicing my invention. Such materials include silicon carbide, fused aluminum oxide, flint, emery, rouge and similar substances. The size of the abrasive particles may vary from the finest polishing or buffing powders to the largest grains now used in the manufacture of sandpaper.

Figure 4 is a greatly enlarged vertical cross-section of a fragment of an included abrasive fibrous web made according to process of the present invention. The individual fibers of the several membranes have been interlocked to form a non-lamellar web structure and the abrasive granules 55 have been distributed internally of the fibrous web. Due to the filtering action of the fibrous web, during the application of the abrasive-adhesive mixture, the number of abrasive particles per cubic unit is greater near the top of the fibrous web than near the bottom, the number per cubic unit gradually decreasing to-

wards the bottom. The granules 55 are firmly anchored in position by being interlocked by the long fibers whose lengths are several times the dimension of the individual grit diameters. While the uppermost granules penetrate through and above the surface of the fibrous web, they are also securely attached by the interlocked fibers, which with the aid of the adhesive binder anchors them in such position that the upper cutting edges are free for grinding and polishing operations.

Figure 5 is a similarly enlarged section of an included abrasive fibrous web in which the grains 55 are so distributed that there is a maximum amount of abrasive grain at both surfaces of the web, with the amount of grain progressively diminishing to a minimum toward the center of the fibrous web.

The physical and abrading properties of the included abrasive webs can be altered to any desired degree by variations in the quantity and character of the adhesive binder agent. The particular adhesive therefor depends upon the specific requirements of the final abrasive product. Latex has been found to be particularly effective as a binder in forming articles of the present invention since it is resistant to water and is also resilient and flexible. Other adhesives, however, which may be used instead of, or along with, latex include liquid animal glue, a waterproof resilient binder such as a synthetic or natural rubber binder or the like, a resinous adhesive in liquid or powdered form, sodium silicate and the like.

One of the important advantages of the invention is that an abrasive article made in accordance with the invention has a resiliency and flexibility which it is impractical to obtain with either paper or cloth. The arrangement of fibers in the base material aided by the latex or other adhesive therein, inherently provides a resilient cushioning which insures that, when the abrasive article is applied to the surface of the work, each abrasive particle will successively contact with the work, the base material yielding so that such contact will be obtained. This property is still further enhanced by proper addition of suitable plasticizers, flexibilizers and the like within the web. Moreover, it has been found that when using the present base material it is possible to use an abrasive which is much coarser and therefore faster cutting to obtain a finish which is as fine or smooth as that obtained by a much finer and therefore much slower cutting abrasive when the latter is backed by paper or cloth. This is a very definite advantage, particularly in the wood sanding operations where fine abrasives clog much more quickly than coarse abrasives.

Another result of the resiliency of the base material is that each particle will have continuity of contact with the work, thus avoiding chattering of the individual particles against the work and the consequent breaking of those particles. The result of course is the more efficient functioning of each particle and consequently for the abrasive article as a whole, resulting in smoother finish and longer life for the abrasive particles.

Alternatively, very brittle characteristics can be imparted to an included abrasive web by the use of a resinous adhesive, which cures to a brittle stage. When the fibers are impregnated with a liquid phenolic resin such as, that sold under the trade name "Durite S-2143," they become quite brittle and as the surface grains become dulled and break away the exposed embrittled fibers also break away and present a fresh layer

of sharp abrasive grains at the grinding surface. Obviously the rate of breakdown of the fibrous membrane can be regulated and controlled to any desired degree by changes in the character and quantity of the embrittling agent and the degree of penetration into the individual fibers.

Included abrasive articles can be produced in which the outer surface, containing the maximum quantity of abrasive grain, is of a brittle character and the opposite side is of a flexible character. Thus one surface of the article functions most efficiently as an abrading device, while the opposite surface provides the necessary flexibility and strength to permit use as a grinding belt, disc and the like. Abrasive materials of such character may be produced by applying an embrittling impregnant to one side of the web and applying a flexibilizing impregnant to the opposite side.

Many advantages accrue from practice of the present invention. For example, as is readily apparent from the description, the present invention readily lends itself to the creation of abrasive articles of specific properties in definite controlled portions of the article without spreading such properties to other parts of the web where they are unnecessary or even undesirable.

Furthermore, the present invention provides an abrasive article which obviates the need for a separate backing or other form of lamination, eliminating the weakness of having a plurality of layers which are liable to split apart during use. The base material is a strong, interwoven structure, especially when internally re-inforced by binding materials or like strengthening agents, but at the same time has interstices which serve to anchor the abrasive particles much better than can be done when they are superimposed upon the face of a backing and are entirely above the surface. Thus the particles are held in place or anchored by what may be termed a double anchorage, achieved by engagement of the particles with the fibers themselves or by engagement of the particles in the adhesive which in turn is anchored to the fibers. Moreover the abrading action of the present products does not stop when a single upper coating of abrasive grain has been removed or destroyed, but continues through a large portion of the base material itself.

The invention having been fully described and explained in its preferred embodiments, it is to be understood that the invention may be embodied and practiced within the scope of the appended claims.

I claim:

1. Apparatus for the manufacture of an abrasive web having a base structure of loosely interwoven fibers with interstices therebetween comprising means for forming such an unlaminated, fibrous web, means for conducting said web into an abrasive grain-applying zone, an air chamber positioned with its orifice facing the web, said orifice shaped to extend substantially transversely of the web, means for maintaining a controlled air pressure in said chamber above atmospheric pressure for inducing a stream of air against the face and into the interstices, of said web, means for introducing abrasive grain into said air stream, means for applying adhesive to the web and for consolidating the same.

2. Apparatus for the manufacture of an abrasive web having a base structure of loosely interwoven fibers with interstices therebetween comprising means for forming such an unlaminated, fibrous web, means for conducting said web into

an abrasive grain-applying zone, means for directing a controlled stream of air against the face and into the interstices of said loosely woven web, means for introducing abrasive grain into said air stream whereby the force of the air stream projects said abrasive grain into the interstices of the web structure, a second means positioned on the opposite side of the travelling web for directing a controlled stream of air against the opposite face and into the interstices of said loosely woven web, means for introducing abrasive grain and other comminuted materials into said second air stream whereby the air stream projects said materials into the interstices of the web structure, means for applying adhesive to the web and for consolidating the same.

3. The method of manufacturing abrasive articles which comprises first forming a loosely woven, open unconsolidated web of considerable depth from a plurality of thin, carded, sheer fibrous membranes, agitating the fibers of said membranes to bring the fibers of each sheer membrane into interlocking position with the fibers of adjoining membranes, thereafter introducing abrasive grains into the interstices between the fibers of said loosely woven, open and unconsolidated web structure, applying a suitable adhesive binder and consolidating the open fibrous structure to anchor the included abrasive grains by the closely surrounding fibers and adhesive, and thereby reducing the web to a relatively thin, strong, abrasive-included sheet.

4. The method of manufacturing abrasive articles which comprises first forming a loosely woven, open, unconsolidated web of considerable depth from a plurality of thin, carded, sheer fibrous membranes, agitating the fibers of said membranes to bring the fibers of each sheer membrane into interlocking position with the fibers of adjoining membranes, thereafter feeding abrasive grains onto the upper surface of the said loosely woven, open, unconsolidated web structure whereby the abrasive grains penetrate into the interstices between the fibers and enter the structure of the web to a considerable depth, applying a suitable adhesive binder, and consolidating the open, fibrous structure to anchor the included abrasive grains by the closely surrounding fibers and adhesive, and thereby reducing the web to a relatively thin, strong, abrasive-included sheet.

5. The method of manufacturing abrasive articles which comprises first forming a loosely woven, open, unconsolidated web of considerable depth from a plurality of thin, carded, sheer fibrous membranes, agitating the fibers of said membranes to bring the fibers of each sheer membrane into interlocking position with the fibers of adjoining membranes, feeding abrasive grains by gravity into the interstices of the said loosely woven, open, unconsolidated web structure to a considerable depth, regulating the direction of travel of the web structure into the pathway of the falling abrasive whereby the degree and amount of the penetration of the grains internally of the web structure is controlled, applying a suitable adhesive binder, and consolidating the open, fibrous structure to anchor the included abrasive grains by the closely surrounding fibers and adhesive, and thereby reducing the web to a relatively thin, strong abrasive-included sheet.

6. Apparatus for the manufacture of an abrasive web having a open, unconsolidated base structure of loosely woven fibers with interstices

therebetween comprising means for forming such an un laminated, fibrous web of considerable depth, means for conducting said fibrous structure into an abrasive grain-applying zone, means for directing a controlled stream of air against the face and into the interstices of said unconsolidated, loosely woven web, means for introducing abrasive grains into said air stream whereby the force of the air stream projects said abrasive grains into the interstices of the web structure to a considerable depth, means for applying adhesive and consolidating the web to a firm, strong abrasive-included sheet.

7. Apparatus for the manufacture of an abrasive web having a open, unconsolidated base structure of loosely interwoven fibers with interstices therebetween comprising means for forming such an un laminated fibrous web of considerable depth, means for conducting said web through an abrasive-applying zone, means for feeding a stream of abrasive grains by gravity onto the upper surface of said web, adjustable means for regulating the direction of travel of the web into the pathway of the falling abrasive grain whereby the degree and amount of the penetration of the grain internally of the web structure is controlled by the angle of striking of the grain into the interstices of the web, means for applying adhesive to the abrasive-laden web and for consolidating the web to a relatively thin, strong, abrasive-included sheet.

8. Apparatus for the manufacture of an abrasive web having a open, unconsolidated base structure of loosely woven fibers with interstices therebetween comprising means for forming such a fibrous web of considerable depth, means for conducting said web into an abrasive grain-applying zone, means for introducing abrasive grain into the interstices of said fibrous web to a considerable depth, means positioned immediately thereafter for applying adhesive to the abrasive-laden web and for consolidating the web to a relatively thin, strong, abrasive-included sheet.

9. The method of manufacturing abrasive articles which comprises first forming a loosely woven, open, unconsolidated web of considerable depth from a plurality of thin, carded, sheer fibrous membranes, agitating the fibers of said membranes to bring the fibers of each sheer membrane into interlocking position with the fibers of adjoining membranes, thereafter projecting abrasive grain by means of an air stream into the interstices between the fibers of said loosely woven, open and unconsolidated web structure, applying a suitable adhesive binder and consolidating the open fibrous structure to anchor the included abrasive grains by the closely surrounding fibers and adhesive, and thereby reducing the web to a relatively thin, strong, abrasive-included sheet.

10. The method of manufacturing abrasive articles which comprises first forming a loosely woven, open, unconsolidated web of considerable depth from a plurality of thin, carded, sheer fibrous membranes, agitating the fibers of said membranes to bring the fibers of each sheer membrane into interlocking position with the fibers of adjoining membranes, thereafter projecting abrasive grain by means of air streams directed at both faces of the web into the interstices between the fibers of said loosely woven, open and unconsolidated web structure, applying a suitable adhesive binder and consolidating the open fibrous structure to anchor the included abrasive grains by the closely surrounding fibers

and adhesive, and thereby reducing the web to a relatively thin, strong, abrasive-included sheet.

11. The method of manufacturing abrasive articles which comprises first forming a loosely woven, open, unconsolidated web of considerable depth from a plurality of thin, carded, sheer fibrous membranes, agitating the fibers of said membranes to bring the fibers of each sheer membrane into interlocking position with the fibers of adjoining membranes, thereafter directing a stream of air against the face of said unconsolidated web, introducing abrasive grain into the air stream whereby the abrasive grain is carried by said air stream into the interstices between the fibers of said loosely woven, open and unconsolidated web structure, applying a suitable adhesive binder and consolidating the open fibrous structure to anchor the included abrasive grains by the closely surrounding fibers and adhesive, and thereby reducing the web to a relatively thin, strong, abrasive-included sheet.

12. The method of manufacturing abrasive articles which comprises first forming a loosely woven, open, unconsolidated web of considerable depth from a plurality of thin, carded, sheer fibrous membranes, agitating the fibers of said membranes to bring the fibers of each sheer membrane into interlocking position with the fibers of adjoining membranes, thereafter projecting abrasive grains by means of an air stream into the interstices between the fibers of said loosely woven, open and unconsolidated web structure, projecting a powdered anti-friction material by means of an air stream directed towards the opposite face of said web into a portion of the unconsolidated web structure, applying a suitable adhesive binder and consolidating the open fibrous structure to anchor the included abrasive grains by the closely surrounding fibers and adhesive, and thereby reducing the web to a relatively thin, strong, abrasive-included sheet.

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