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R. L. MELTON ET AL

2,307,698

MANUFACTURE OF ABRASIVE ARTICLES

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2 Sheets-Sheet 1

Fig. 1.

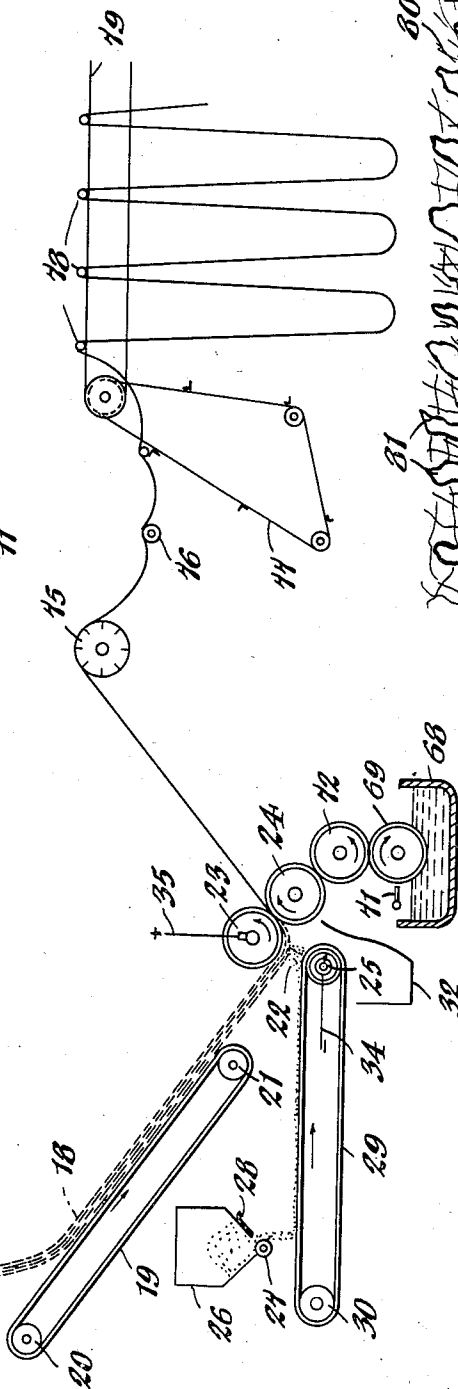
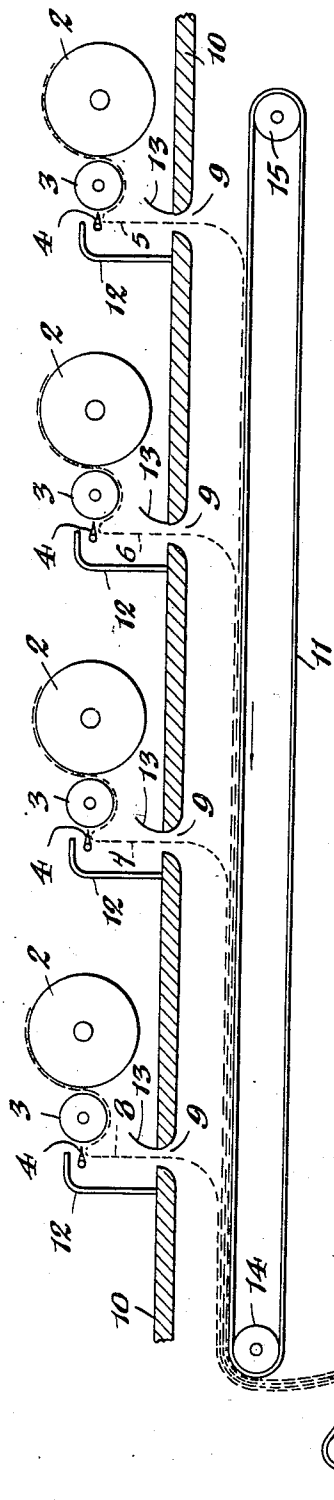
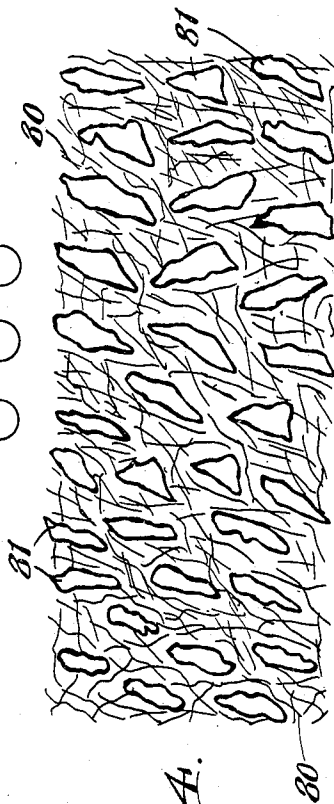


Fig. 4.



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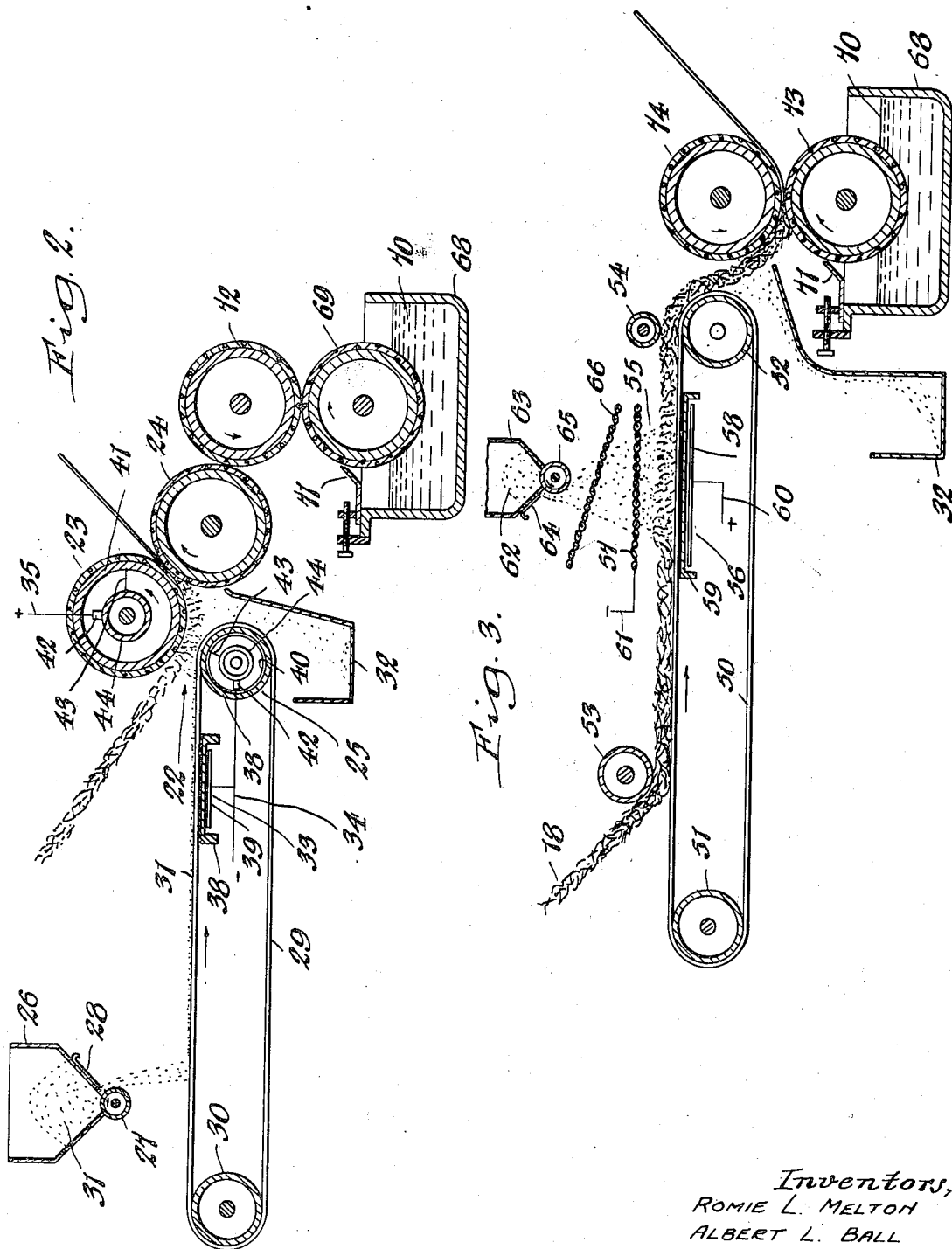
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MANUFACTURE OF ABRASIVE ARTICLES

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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MANUFACTURE OF ABRASIVE ARTICLES

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12 Claims. (Cl. 51-294)

This invention relates to the manufacture of abrasive articles and especially to a process of making abrasive webs or sheets of felted, fibrous material in which the abrasive element is distributed internally of the fibrous structure. More particularly, it is concerned with a method of projecting or otherwise introducing the abrasive grains into the web by means of electrical forces whereby the fibrous structure of the web is distended to open up the interstices between adjoining fibers simultaneously with the introduction of the abrasive particles so as to provide a more ready reception and deeper penetration of the abrasive material internally of the web. At the same time, when the abrasive particles are elongated in shape the projection of the abrasive particles by electrical forces orients the particles as they enter the fibrous structure so as to deposit the abrasive particles within the web with their long axes oriented with respect to the web surface, resulting in an improved cutting behavior of the finished product. The invention further relates to the formation of flexible abrasive webs in the above manner in which various modifying agents are incorporated in the web to impart specific desired properties to all or portions of the web structure.

So-called coated abrasive articles, such as abrasive paper and cloth, discs and the like, are old and well known in the art, but the present invention should not be confused with such articles since it deals with a product which differs therefrom by the absence of the conventional backing. The present product represents an improvement over such articles by reason of the elimination of the backing and may be used for many purposes for which abrasive paper is adapted as well as in applications for which the conventional abrasive paper is not suited. In addition, its fibrous structure lends a strength and durability to the final product not to be expected in a backless product.

Felted fibrous web material has been made by building up a layer of the desired thickness from a plurality of superimposed thin membranes. Such felted fibrous webs have also been made in which abrasive particles have been introduced into the webs at the time of making and also in which the finished webs have been employed as supports for a top facing of abrasive grains adhesively secured to the surface. The abrasive material has been added to the fibrous material by sifting it onto the web at the time of making or by blowing the abrasive grains into the web with a blast of air. Abrasive particles of smaller sizes have been included in such web material by

incorporation of the abrasive powder in a liquid adhesive which then carries the abrasive particles into the web as the adhesive penetrates the web.

It is an object of the present invention to provide an improved process of introducing abrasive material internally of the web whereby the abrasive particles can be caused to be presented to the web so as to penetrate more deeply without undue disturbance or disruption of the fibrous structure in the operation, and moreover, the abrasive particles can be placed within the web structure in oriented position. At the same time the present invention serves to simultaneously prepare the fibrous web for a favorable reception of the abrasive material into the web.

In accordance with the present invention, a loosely interwoven, felted fibrous web is first formed by any suitable procedure. For example, such a web may be formed by superimposing a plurality of thin carded fibrous membranes upon a moving support in sufficient number to build up a loose, uncompacted web of the desired thickness. While the web is in its uncompacted state it is passed through an electrostatic field whereupon the electrostatic forces of the field cause the fibrous structure of the web to become distended and the interstices formed by the adjoining interlocked fibers to be opened up to a position favorable for the introduction of abrasive material internally of the web. While the fibrous web is in the above distended condition, abrasive particles are introduced into the electrostatic field whereupon the action of the electric field upon the abrasive material causes it to become electrically charged and projected into the opened fibrous web structure. Particles of granular abrasive material in crushed form often have an irregular shape of a substantially elongated nature in which the major or lengthwise axis of the granule is considerably greater, sometimes mounting to several times, the length of the minor axis. During the projection of such abrasive grains into the web the individual particles of the abrasive become oriented in a direction depending upon the position of the electrode toward which the abrasive particles are attracted. The orientation of such elongated abrasive particles is usually such that the grains are projected into the web with their long axes substantially normal to the surface of the web, although the orientation may also be such that the grains are presented with their long axes at any controlled degree of obliqueness to the web surface. By the interjection of the fibrous web between the source of abrasive

particles within the electrostatic field and the electrode toward which the particles are attracted the abrasive particles become projected and oriented in the desired direction internally of the fibrous web. By reason of their orientation and also because of the opened-up, distended condition of the fibrous structure at the point of projection the abrasive particles are presented to the web so as to cause a minimum disruption or disturbance of the fibers and the maximum amount of penetration of the web. After the fibrous web has been thus loaded with abrasive grain a suitable adhesive binder is applied to the web and it is compacted to the desired density.

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

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 vertical diagrammatic cross-section of an apparatus for making flexible, abrasive-included fibrous webs in accordance with the teachings of the present invention;

Figure 2 is an enlarged vertical cross-section of that portion of the apparatus for the electrostatic treatment of the web and projection of abrasive particles into the web and the compacting thereof;

Figure 3 is an enlarged vertical cross-section of a modified form of the apparatus shown in Figure 2; and

Figure 4 is a vertical cross-sectional view on a greatly exaggerated scale showing a portion of a fibrous abrasive-loaded web formed by the method of the invention.

In Figure 1 is illustrated one form of apparatus which may be employed in manufacturing abrasive webs comprising a felted fibrous material with abrasive grains incorporated therein and bonded with a suitable adhesive. The particular apparatus shown comprises a plurality of carding machines, suitably spaced apart and consisting of carding rolls 2, stripper rolls 3 and combs 4, adapted to form and deliver a number of fibrous membranes or laps 5, 6, 7 and 8 to the moving conveyor 11.

The carded membranes or laps are delivered from the carding machines as flimsy webs of independent fibers generally parallel and loosely adhering together. The carded membranes may consist of any animal, vegetable or synthetic fibrous material capable of being carded into yarn or sheet form. While cotton fibers have proven to be highly satisfactory for the present process, other fibers suggested for use are such natural fibers as wool, jute, flax and the like, or any of the newer synthetic fibers such as glass wool, resinous or synthetic rubber fibers. Also, instead of having all the fibers of the same material, one or more of the fibrous membranes may be a different fiber than the rest. Although only four carder assemblies are shown in Figure 1, any number of carders may be used depending upon the desired thickness and type of fibrous web.

The carded membranes are discharged through orifices or slots 9 in the floor 10 and onto the continuously moving conveyor belt 11 which is slightly wider than the width of the deposited membranes. As the membranes pass through the

slots 9 they are shielded from any undesirable external influences, such as strong air currents, by the surrounding sidewalls 12 and 13. The conveyor belt 11 is provided with a smooth outer surface and is supported at the opposite ends thereof by the rolls 14 and 15, which are driven by any suitable means (not shown). The speed of the belt is synchronized with the rate of feed of the membranes so as to prevent any appreciable strain or pull on the flimsy membranes during their deposition.

The individual laps 5, 6, 7 and 8 are applied successively to form a composite layer of proper thickness and character. The number and arrangement of the carding assemblies will depend upon the desired thickness and type of fibrous web produced.

After the loosely felted, uncompacted web 18 has been built up to the required thickness it is ready to be conveyed to the apparatus for introducing the abrasive material into the web. The web 18 is fed onto a moving conveyor belt 19, which is supported by the synchronously driven rolls 20 and 21, and delivered through the electrostatic field 22 for distending the web and projecting the abrasive grains into the web, from which the web is conducted immediately between the adhesive binder-applying rolls 23, 24.

As the uncompacted fibrous web moves into the electrostatic field 22 created between electrodes 23 and 25 which extend the full width of the web 18 and are positioned above and below the moving web, the individual fibers tend to become disarranged and are shifted from their normal parallel position (assumed as a result of the carding operation) so as to assume partially upright or upended positions. The individual fibers are caused to intertwine to a greater degree and thereby produce a firm, homogeneous, interlocking structure which will be non-lamellar in final appearance. As a result of this agitating action of the electrostatic field, the web structure becomes distended and the interstices between adjoining fibers are opened up so as to be more receptive of the projected abrasive particles.

The electrostatic means and associated apparatus for accomplishing this distending action and for projecting the abrasive grains into the web and orienting the abrasive particles therein are shown in greater detail in Figure 2 of the drawings. The electrically charged electrodes and the particular manner in which they are positioned and used for the distention of the fibrous web and the deposition of the abrasive grains into the web is clearly depicted. The fibrous web 18 passes from the conveyor belt 19 into the electrostatic field 22 which is created between electrodes 23 and 25. As it enters the electrostatic field the electrical forces thereof cause the fibrous structure to become distended and the individual fibers thereof to be partially upended so as to open up the interstices between adjoining fibers and prepare the web for a more favorable reception and penetration of the granular material. Simultaneously, abrasive grains are fed in a constant stream from a hopper 26 by means of a regulating roll 27 and adjustable gate 28 onto a moving conveyor belt 29 which is supported by end rolls 25 and 30, roll 25 of which also constitutes one electrode of the electrode pair. The abrasive granules 31 are carried on the belt 29 into the electrostatic field 22 where they receive an electrostatic charge, become oriented, and are projected into the distended fibrous web. The excess abrasive grains pass

over the end of the conveyor belt and drop into a suitable receptacle 32.

An auxiliary or secondary electrode 33 having the same polarity as the electrode 25 is optionally positioned beneath the moving grain-carrying belt 29 to serve as a precharging electrode for imparting an electrical charge to the abrasive granules preparatory to their entering the electrostatic projecting field 22.

The source of electromotive force for creating the electrostatic field, the effective potential of which is 20,000 volts or more, is not specifically shown in the drawings, but is indicated by the positive (+) and negative (-) symbols and connected to the electrodes 25, 33 and 23 by the connecting lead wires 34 and 35, respectively. The revolving cylinder electrodes 23 and 25 are connected to the source of electromotive power through a slip ring of well known type connected to the metallic rings 40 and 41 by means of brush contacts 42, flexible connectors 43 and slip rings 44. The source of electromotive force may produce a continuous unidirectional current, an intermittent unidirectional current, or an alternating current depending upon the particular requirements. The effects of direct current and alternating current electrostatic fields will be described hereinafter in greater detail. When a unidirectional current source is utilized it is preferable that the upper electrode 23 be connected to the positive terminal and the lower electrodes 25, 33 be connected to the negative terminal. However, if desired, the polarity of the electrodes may be reversed, and as a safety measure it is desirable that the upper or bare metal electrode be grounded.

The character and construction of the lower electrodes 25 and 33, and particularly electrode 25, are of great importance in the operation of the apparatus and, preferably, are shielded by some "poorly conducting" material. The materials so used should be low enough in conductance that not enough current can flow along or through it to cause arcing between the upper and lower electrodes, yet it should be sufficiently conductive to allow a small leakage current to supply electrical charges to the abrasive particles in order that they may be oriented so that their lengthwise axes are normal to the web direction and most suitable for projection into the fibrous structure and also for distension and preparation of the fibrous structure for reception of the projected particles. Therefore the lower or high potential electrodes 25 and 33 are formed of a poorly conducting material 38 which completely surrounds the metallic plate 39 of electrode 33 and the hollow metallic tube or lining 40 of electrode 25. In speaking of a poorly conducting material this expression is used to distinguish between such materials as metals, carbon, or the like, which are relatively good conductors of electricity, on the one hand, and highly insulating materials such as hard rubber, varnished cambric or the like, which are such good insulators at the voltage preferably used with the present apparatus that the leakage current which flows through them is insufficient to electrically charge the abrasive particles or influence the fibrous web on the other hand. For this purpose molded materials, such as those sold under the trade names of "Micarta" and "Bakelite" have been found to be most satisfactory. However, other materials such as dry, knot-free wood can also be used. While these materials are so poorly conducting that they will

not carry enough current to permit "spark-over" or arcing between the upper and lower electrodes, they are sufficiently conductive at the voltages employed to allow enough leakage current to pass and supply the small amount of electrostatic charges required.

Ordinarily the upper cylinder electrode 23 is at ground potential and thus does not need to be encased by a poorly conducting sheath.

Figure 3 illustrates a modified form of electrostatic apparatus for distending the fibrous web and orienting and projecting the abrasive particles into the distended web. This apparatus differs from that shown in Figures 1 and 2 in that the uncompacted fibrous web is fed from a carrier belt such as belt 10 shown in Figure 1 onto a horizontal secondary carrier belt 50 which is supported by end rolls 51 and 52 and is driven at the same speed as that of the web in order not to exert any appreciable strain upon the uncompacted fibrous web. The guide rolls 53 and 54 placed at or adjacent the opposite ends of the carrier belt 50 and slightly above its upper surface serve to hold the web in position and prevent it from being displaced, although they do not serve as a compressing means. As the web 10 passes along the carrier belt 50 it passes through an electrostatic field 55 created between the electrode 56 positioned beneath the upper surface of the carrier belt and the screen grid electrode 57 positioned above the carrier belt but suitably spaced therefrom. This electrostatic field is produced by a source of electromotive force, the effective potential of which is 20,000 volts, or more, not specifically shown in the drawings, but indicated by the positive (+) and negative (-) reference characters. The lower electrode 56 is constructed similar to electrode 33 of Figure 2 and consists of a metallic plate 58 shielded by a poorly conducting material 59, and connected to the source of electromotive force by connecting wire 60. The upper electrode consists of a screen grid which permits the passage and distribution of gravity-fed abrasive grain therethrough into the electrostatic field and is connected to the source of electromotive force by connecting wire 61. Abrasive grain 62 is fed from a supply hopper 63 equipped with grain feeding control gate 64 and roll 65 for depositing a steady controlled stream of abrasive grain through the auxiliary screen 66 which serves to additionally distribute the grains evenly over the entire area of the screen grid electrode 57.

In employing an electrostatic field to project the abrasive particles into the web it has been found that in projecting the larger grit sizes the unidirectional electromotive force is particularly effective since it serves to distend and open up the interstices of the web structure and permit a deeper and more pronounced penetration of the web without interruption by the fibers. This double action of the electrostatic field of opening the web and orienting the abrasive grains serves to permit a larger quantity of abrasive to be effectively distributed throughout the internal structure of the web. On the other hand, alternating current provides an electrostatic field which is very effective in giving a limited penetration, especially of the finer grit sizes, whereby the fibrous web structure is not distended in the degree accomplished by the unidirectional current field and is desirable in the making of certain fine grit products.

After the fibrous web has been sufficiently

loaded with abrasive grain in the manner described, it is ready to be consolidated to a greater density for added strength. At the same time it is desirable to incorporate a liquid adhesive binder within said web to bond the compacted fibers and abrasive grains and product a web of greater density having a strength comparable to that of cloth.

The abrasive-laden fibrous web is conducted from the electrostatic field between a pair of pressure rolls which serve to apply adhesive, force the adhesive into the web and compact the web to the required density. In the apparatus shown in Figures 1 and 2 the cylinder electrode 23 serves the additional function of cooperating with the adhesive-applying roll 24 to compact the web. The liquid adhesive binder is contained in a pan, which may be water-jacketed and heated as required. Roll 69 is partially immersed in the liquid adhesive 70 and as it revolves, a quantity of adhesive binder, determined by the adjustably spaced scraper bar 71, is applied to the web. The adhesive is transferred to roll 24 from roll 69 by means of transfer roll 72. Roll 23 is adjustably spaced with respect to the adhesive roll 24 and applies sufficient pressure to finally compact the loose fibrous web as well as aid in forcing the binder to permeate into and throughout the web structure. The surface of roll 24 should be covered with a resilient layer of absorbing material.

In Figure 3 the adhesive pick-up roll 73 serves also to apply the adhesive to the fibrous web without the requirement of transfer rolls and serves also to cooperate with pressure roll 74 to suitably compact the web to the desired density and force the adhesive to permeate and penetrate into the fibrous web structure.

The adhesive binder used to permeate and assist in maintaining the consolidated condition of the web is preferably one of a flexible or resilient nature, such as latex, flexibilized animal or vegetable glue, plasticized vinyl resin, plasticized urea formaldehyde resin, and the like. Such flexible adhesives permit the retention of the natural pliable character of the interlocked fibrous structure.

Also, in practicing the invention any of the abrasive materials in common use may be employed, such as silicon 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.

After the web is compacted and the proper amount of adhesive binder applied therethrough, it is passed over a suction drum 75 and idler roll 76 to a suitable chamber where it is dried or cured. This chamber contains an endless conveyor 77 which serves to festoon the web onto supporting sticks 78 and to transport these sticks and looped material to the moving rack 79. The speed of the moving rack 79 is so adjusted that the adhesive binder is properly set or cured by the time it reaches the end of the chamber. When the abrasive web material is taken down from the drying rack it is wound into rolls or cut into sheets suitable for use.

Figure 4 is a greatly enlarged vertical cross-section of a fragment of an abrasive-included fibrous web made according to the present invention, in which web the individual fibers 80 of the fibrous structure are interlocked and interwoven about the abrasive granules 81, firmly anchoring them in place. The abrasive granules 81 have been projected into the fibrous web and

oriented therein so that the majority of the individual grains are substantially in a perpendicular position with respect to the surface line of the fibrous web, and moreover are distributed throughout the interior of the web.

While the preferred embodiments of the invention have been specifically illustrated and described, it is to be understood that the invention may be otherwise embodied and practiced within the scope of the appended claims.

We claim:

1. A method of making flexible, fibrous abrasive web material having abrasive particles included therein which comprises depositing a plurality of thin carded, fibrous membranes in superposed relationship upon a suitable moving support to form a felted fibrous web, passing said fibrous web through an electrostatic field to distend and open up the fibrous structure of said web, introducing abrasive granules into said electrostatic field and thereby orienting and projecting said particles by means of the electrical charge collected thereon into the interstices of the fibrous web, applying adhesive to the abrasive-laden fibrous web and compacting the web to the desired density.

2. A method of making flexible, fibrous abrasive web material having abrasive particles included therein which comprises depositing a plurality of thin carded, fibrous membranes in superposed relationship upon a suitable moving support to form a felted fibrous web, passing said fibrous web into an electrostatic field, introducing abrasive particles into said electrostatic field, projecting said particles into the web by means of the electrostatic forces of said field, applying adhesive to the abrasive-laden fibrous web and compacting the web to the desired density.

3. A method of making flexible, fibrous abrasive web material having abrasive particles included therein which comprises forming an uncompacted web of felted, fibrous material, passing said uncompacted fibrous web through an electrostatic field, introducing abrasive particles into said electrostatic field so as to electrically charge and project the particles internally of the loose fibrous web, applying adhesive to the abrasive-laden web and compacting the web to the desired density.

4. A method of making flexible fibrous abrasive web material having abrasive particles included therein which comprises forming an uncompacted web of felted fibrous material, passing said uncompacted fibrous web through an electrostatic field, introducing abrasive particles into said electrostatic field so as to electrically charge and orient the particles, projecting said oriented particles internally of the loose fibrous web, applying adhesive to the abrasive-laden web and compacting the web to the desired density.

5. A method of making flexible, fibrous abrasive web material having abrasive particles included therein which comprises forming a loosely felted web from a plurality of superimposed thin carded fibrous membranes, passing said fibrous web through an electrostatic field, introducing abrasive particles into said electrostatic field so as to electrically charge and project the particles internally of the loose fibrous web, applying adhesive to the abrasive-laden fibrous web and compacting the web to the desired density.

6. A method of making flexible, fibrous abrasive web material having abrasive particles included internally thereof which comprises form-

ing an uncompacted web of felted, fibrous material, passing said uncompacted fibrous web through an electrostatic field to distend and open up the fibrous structure of said web, feeding abrasive particles upon a moving support, carrying said abrasive grains into said electrostatic field and projecting said abrasive particles internally of the fibrous web while the fibrous structure of said web is in distended condition, immediately thereafter applying adhesive to the abrasive-laden web and compacting the web to the desired density.

7. A method of making flexible, fibrous abrasive web material having abrasive particles included internally thereof which comprises forming an uncompacted web of felted, fibrous material, passing said uncompacted fibrous web through an electrostatic field to distend and open up the fibrous structure of said web, feeding abrasive particles by gravity through a screen into said electrostatic field to orient said abrasive particles, introducing the oriented abrasive particles into the distended fibrous structure of said web, applying adhesive to the abrasive-laden fibrous web and compacting the web to the desired density.

8. In the process of making flexible, fibrous abrasive webs having abrasive particles included internally thereof the steps which comprise passing an uncompacted fibrous web material through an electrostatic field to distend and open up the fibrous structure thereof and simul-

taneously projecting abrasive particles into the web by means of electrostatic forces while said web is in a distended condition.

9. An abrasive article comprised of a flexible, felted fibrous web of cardable fibers having abrasive particles included internally of said web and held in position therein by an adhesive binder, substantially all of said abrasive particles being oriented within said web.

10. A felted fibrous, abrasive web composed of a plurality of superimposed thin carded fibrous membranes adhesively compacted together and having abrasive particles distributed throughout the interior of said web structure and oriented therein.

11. A felted fibrous, abrasive web composed of a plurality of superimposed thin carded fibrous membranes adhesively compacted together and having abrasive particles distributed throughout the interior of said web structure and oriented therein with their major axes substantially all normal to the surface of the fibrous web.

12. A felted fibrous, abrasive web composed of a plurality of superimposed thin carded fibrous membranes adhesively compacted together and having abrasive particles distributed throughout the interior of said web structure and oriented therein with their major axes lying obliquely to the surface of the web.

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