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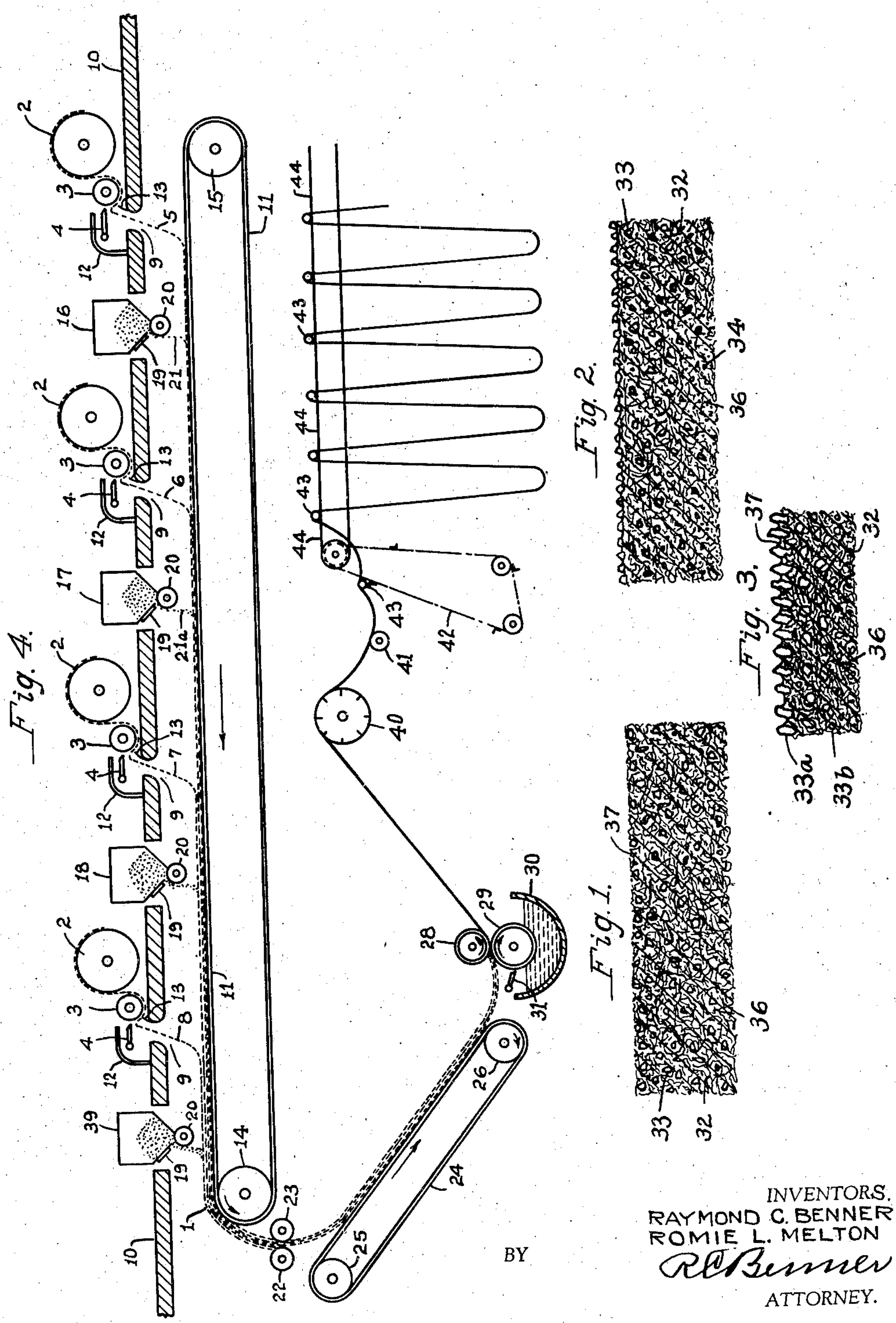

INVENTORS.
RAYMOND C. BENNER
ROMIE L. MELTON

BY R C Benner

ATTORNEY.

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MANUFACTURE OF ABRASIVE ARTICLES

Raymond C. Benner and Romie L. Melton, Niagara Falls, N. Y., assignors to The Carborundum Company, Niagara Falls, N. Y., a corporation of Delaware

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This invention relates to flexible abrasive webs and to methods of manufacturing said webs. More particularly, it relates to abrasive materials comprising a felted fibrous structure with abrasive grains incorporated internally of the web and/or extending in part above the surface thereof. The invention also pertains to fibrous abrasive webs in which modifying agents, binders and the like have been incorporated to impart desired properties thereto.

This application is a continuation-in-part of our co-pending application Serial No. 343,150, filed June 29, 1940.

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 differs therefrom by the absence of the conventional backing. It 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.

We have found that abrasive web materials can be readily and quickly produced by collecting loose fibers in any desired form, as for example, in a continuous sheet, and incorporating abrasive material therein. The present invention, therefore, provides a flexible fibrous abrasive web material in which the abrasive grain is distributed internally of a loose flimsy web of any suitable fibrous material. 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 upper abrading surface. In other words, webs having an upper surface application of abrasive grains as herein provided are so constructed that the abrasive grain and adhesive binder permeates and penetrates the fibrous web within the interstices between the individual fibers which then assist in holding the projecting abrasive grain firmly in position.

Abrasive grain can be introduced entirely or partially within the 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 flat surface of the web with the amount of abrasive grain progressively diminishing as the distance from that surface of the web becomes greater, there being little or no abrasive grain at the opposing or back surface of the web. However, if desired the grain may be evenly and uniformly distributed as to amount or size throughout the web, or it may be applied in such a manner that the quantity of grain diminishes equally from both surfaces of the web toward the interior. Similarly there may be created an abrasive-containing web in which there is a graduation of grit size of abrasive grain through the web from one surface to the opposing surface. A coating of abrasive grain may also be applied, if desired, and adhesively secured to the top surface of the web, although the last application of internally applied abrasive grain protrudes from the fibres which help to hold it in position and is sufficient to effectively and efficiently carry out polishing or grinding operations. A sizing or surface application of adhesive may be applied to the layer of abrasive grains in order to anchor them more firmly in position.

Various modifying agents, such as water-proofing 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 desirable properties to the web. The amount and distribution of each specific modifying agent would depend upon the desired web properties and the particular portions of the web to be affected thereby.

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

Figure 1 is a greatly enlarged vertical cross-section through a fragment of an abrasive web embodying the present invention;

Figure 2 is a similarly enlarged vertical cross-section of a modified form of abrasive web;

Figure 3 is still another modification of the invention; and

Figure 4 is a diagrammatic side elevation, partly in section, showing one form of apparatus for making abrasive webs according to the present invention.

In Figure 4 we have 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. These membranes may consist of any fibrous material capable of being carded into web form or separable into individual fibers. Such materials include natural fibers, such as cotton, wool, jute, flax and asbestos, as well as the various synthetic fibers, such as glass wool, resinous and rubber-like fibrous substances. 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 method of manufacture.

The carded membranes are discharged through orifices or slots 9 in the floor 10 and onto a 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 surrouding 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.

Abrasive grains may be incorporated internally of the fibrous web by any one of several methods, such as by applying the grain to the deposited membranes during the steps of building up the web on the conveyor belt. Suitable apparatus for carrying out this step of the operation is illustrated in Figure 4 of the drawing, in which the abrasive grain is fed in regulated amounts from the several grain hoppers 16, 17 and 18, each of which is provided with an adjustable feed gate 19 and cooperating grain distributing roll 20. After one or more layers of fibrous membrane have been deposited on the carrier, the feed gate 19 of grain hopper 16 is adjusted to feed a very thin stream of abrasive grain 21 onto the fibrous membrane. The next membrane 6 is then applied over this layer of deposited grain and the next increment of abrasive grains 21a deposited from the hopper 17, the amount of grain being somewhat in excess of the amount of grain previously applied from hopper 16. In this way alternate layers of abrasive grain and membranes or laps are deposited upon the conveyor belt and each successive application of abrasive grain may be heavier in amount than the previous application. If however, a uniform distribution of grain through the web is desired, then the grain feed from the several feeding devices would be correspondingly adjusted.

The particle size of the abrasive material may also be varied from hopper to hopper, in which case the smallest particles may be applied from the first bin 16 and the size of the abrasive particles gradually increased in the successive bins 17 and 18. While only four bins for abrasive grains and four carding machines have been shown, it is to be understood that any number of layers of abrasive grain and carded membranes may be incorporated to produce a composite web of any desired thickness and character.

In practicing our 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.

It is desirable, in certain instances, to incorporate an adhesive binder between the successive layers of fibrous membrane. This adhesive may be in powdered or liquid form and may be either a glue, resin, rubber or rubber-like material. Such adhesives may be applied in any suitable manner, such as for example, mixing with the abrasive grains and applying from the grain hoppers 16, 17 and 18, or separate hoppers and feed rolls may be utilized. Alternatively, the abrasive grains may be individually coated with a suitable adhesive prior to deposition onto or inclusion within the fibrous web. The adhesive may also be applied as a liquid in finely atomized form from suitable spray nozzles, provided the atomizing pressure is kept sufficiently low to avoid disturbing the flimsy membranes.

The abrasive-containing fibrous web may be further modified by the application of various modifying agents during various stages of the building up of the web in the same way in which the adhesive is added and in any required amount. For example, the web can be waterproofed by the application of a waterproofing agent to the membranes as they lie on the carrier belt, or by the use of a waterproof adhesive binder. Again antifriction ingredients of soapstone, graphite, and the like, can be similarly incorporated in those laps or membranes making up the portion of the web immediately adjacent the back surface. At any stage in the building up of the web, flexibilizing, embrittling, or other agents may be similarly incorporated.

After the fibrous abrasive web 1, with or without adhesive binders and/or modifying agents, has been built up to the required thickness it is ready to be compacted to a greater density for added strength. At the same time it is usually desirable to incorporate a liquid adhesive within said web to bond the compacted fibers and produce a dense web having a strength comparable to that of paper or cloth.

The web 1 is initially compacted by the synchronously driven squeeze rolls 22 and 23, which may be located near the terminus of the supporting belt 11. One or both of these rolls may have a resilient surface or they may have a roughened surface possessing a multiplicity of small projecting points. In either case the individual fibers of each successive lap or membrane are pressed down and around the base of each individual abrasive particle, securely anchoring it in place, and causing the uppermost grains to project above the web surface to form an extremely sharp and fast cutting abrasive material.

Passing from the compacting rolls the web is fed onto a moving conveyor belt **24**, which is supported by the synchronously driven rolls **25** and **26**, and delivered to the adhesive binder applying rolls **28**, **29**. The liquid adhesive binder is contained in a pan **30**, which may be water-jacketed and heated as required. Revolving roll **29** is partially immersed in the adhesive and with each revolution transfers a quantity of adhesive binder, determined by the setting of the adjustable scraper bar **31**, into the fibrous web. Roll **28** applies sufficient pressure to finally compact the loose fibrous web and aids in forcing the binder adhesive to permeate throughout the web. The surfaces of both rolls **28**, **29** are covered with a resilient layer of absorbing material.

After the abrasive web is compacted and the proper amount of adhesive binder applied therethrough, it is passed over a suction drum **40** and idler roll **41** to a suitable chamber where it is dried or cured. This chamber contains an endless conveyor **42** which serves to festoon the web onto supporting sticks **43** and to transport these sticks and looped material to the moving rack **44**. The speed of this moving rack **44** is so adjusted that the material is properly set or cured by the time it reaches the end of the chamber.

When the abrasive material is taken down from the rack it may be cut up into sheets, discs or belts of suitable size or additional coatings may be applied as will be hereinafter described.

In a modified form of the present process, we may apply an additional layer of abrasive grains to the outer surface of the web after the fibrous abrasive web has been built up and compacted. In carrying out this additional step of the process, we apply a layer of adhesive to the outer side of the fibrous abrasive web by conventional adhesive applying means, such as the glue pan **30**, adhesive roll **29**, and a pressure roll **28**. A layer of abrasive grain of predetermined thickness may be applied to the adhesively coated surface of the web by any of the well known methods for applying abrasive grains, such as, for example, an arrangement similar to the grain hopper **18** and the grain distributing roll **20** shown in Figure 4. The conventional sizing layer of adhesive is applied over the deposited layer of abrasive grains by the usual adhesive rolls, similar to those used in spreading the base coating of adhesive.

The surface coating of abrasive grain may be applied at any time before or after partial or complete drying and curing of the abrasive filled fibrous web.

The abrasive grain may be applied to a preformed fibrous web by gravitational forces, as described above, or by the more recently developed electrostatic, magnetic or mechanical methods of grain deposition. In these new grain deposition units, electrical and/or mechanical forces are utilized to orient the elongated abrasive particles and project them onto the fibrous web so that they are positioned with their longer axis substantially perpendicular to the surface of the web. 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 R. L. Melton, R. C. Benner and H. 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; and suitable magnetic orientation and projection apparatus is illustrated and described in Patent No. 2,254,531, issued September 9, 1941, to the same inventors.

In another modification of the present process the abrasive grains may be applied to a previously formed lap or web. The formed lap may be moved past a single grain applying means, such as the hopper **39** and its cooperating grain feed roll **19**, where the entire amount of grain may be deposited on and into the fibrous web at one application and then the adhesive binder applied into the abrasive filled lap by the rolls **28**, **29**. Or, if desired, and particularly with the finer abrasive materials (220 mesh in size and smaller) the grain may be uniformly mixed with the adhesive in the pan **30** and both the abrasive and the adhesive binder applied simultaneously to the already formed fibrous web. In either case the abrasive grain is lodged in the open spaces within the web and held in place by the surrounding fibers and adhesive.

Figure 1 is a greatly enlarged vertical cross-section of a fragment of an abrasive fibrous web made according to the present invention, in which web the individual fibers **32** of the various membranes have been pressed around the bases of the individual grains **33**, firmly anchoring them in place. The abrasive granules **33** have been distributed throughout the web in such a way that there is a maximum amount of abrasive grain at the top surface **37** of the web with the amount of abrasive grain progressively diminishing to a minimum at the back surface **36**.

Figure 2 shows a web fragment similar to that shown in Figure 1, in which an anti-friction agent **34** has been incorporated in that portion of the web nearest the back surface **36**. An outer surface coating of abrasive grain **35** has also been applied to the top side of the web.

Figure 3 is a modified web made according to the present invention wherein the abrasive grains incorporated in the web show a gradation of grit size from the large grit grain **33*a*** at the top surface **37** of the web down to the small grit size **33*b*** nearest the back **36** of the web.

Figures 1, 2 and 3 clearly show how the abrasive grains are held in place by being intertwined by the long fibers whose lengths are several times the dimension of the individual abrasive grit diameters. Furthermore, the uppermost granules penetrate through and above the top layer of membrane fibers, which with the aid of an adhesive binder anchors them in such position that the upper cutting edges are free for grinding and polishing operations.

We have found that the character of the abrasive material produced by the herein-described process can be altered to any desired degree by variations in the quantity and character of the adhesive binder employed. By the addition of an embrittling agent or the use of a resinous adhesive which cures to a brittle stage, we are able to produce an article in which the fibrous materials break away and expose new abrasive grains during subsequent abrading operations. Thus the multi-layer abrasive article acts in a manner similar to that of a grinding wheel. As the surface granules become dulled and are broken away, the impregnated and brittle fibers which are exposed 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 impregnating agent and the degree of penetration into the individual fibers. The degree of penetration of the individual fibers may be regulated by the use of various textile wetting out agents which are well known in the industry.

Very brittle characteristics may be imparted to the fibrous membrane by impregnating with a liquid phenolic resin such as that commonly sold under the trade name "Durite S-2143." Sufficient resin should be incorporated in the fibrous web so that the resin comprises from 30% to 60% by weight of the impregnated fibrous material. The impregnated material may then be cured for approximately 2 hours at a temperature of 200° to 250° F. If increased brittleness is desired, the length of the heat treatment may be extended and the curing temperature raised to 300° F.

A fibrous abrasive web possessing a lesser degree of brittleness may be produced by impregnating the fibers of the web with glue under conditions which will leave a dry glue residue of from 20% to 60% by weight of the impregnated fibrous membrane.

Flexibilizing agents may be incorporated in a portion of the web or distributed throughout, depending upon the type of product desired. Impregnation with a long oil synthetic resin varnish, such as that made by Pratt and Lambert and designated by them as "No. 1767," produces a strong and very flexible web. Sufficient varnish should be incorporated so that it will comprise 20% to 40% by weight of the impregnated fibrous web. The varnish may be cured by heating for approximately 2 hours at a temperature of 200° F.

In cases where a less flexible material is desired, we may use a material such as that sold under the trade name "Bakelite" varnish "No. BV-6509" as the impregnant. Sufficient varnish should be incorporated in the web so as to leave a dry residue of 20% to 40% by weight, and the impregnated material cured from 2 to 4 hours at a temperature of 250° to 280° F.

Various plasticizers, such as glycerine, dibutylphthalate, and the like may be added to the varnish impregnating agents in order to increase their flexibility. The quantity of such material employed will depend upon the desired flexibility characteristics of the finished product and may, in some instances, amount to 40% of the combined weight of the varnish and plasticizer.

We have also found that 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.

The character of the abrasive web may be varied within wide limits by regulating the relative quantity of embrittling and flexibilizing agents applied to the opposite sides of the web and the depth of penetration therein.

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 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 fibrous membrane structure, when compacted and reinforced with an adhesive binder, provides a strong supporting material and the abrasive grains included therein are firmly anchored in position. The grains are held in place by what may be called a double anchorage, achieved by engagement of the individual fibers entwined around the base of each individual grain and the adhesion of the binder agent.

Another important advantage is that an abrasive article made in accordance with the invention possesses a resiliency and flexibility which is impractical to obtain with abrasive coated paper or cloth.

While we have specifically illustrated and described the preferred embodiment of our invention, it is to be understood that the invention may be otherwise embodied and practised within the scope of the following claims.

We claim:

1. The process of manufacturing flexible abrasive webs which comprises feeding a plurality of thin carded fibrous membranes onto a moving endless support, applying abrasive grain to the deposited fibrous membranes, alternating the deposition of additional fibrous membranes and abrasive grain until the web has been built up to the desired thickness, applying suitable adhesive binder and compacting the web.

2. The process of manufacturing flexible abrasive webs which comprises feeding a plurality of thin carded fibrous membranes onto a moving endless support, applying abrasive grain to the deposited fibrous membranes, alternating the deposition of additional fibrous membranes and abrasive grain until the web has been built up to the desired thickness, incorporating a waterproofing agent in said web to render it substantially water resistant, applying suitable adhesive binder and compacting the web.

3. The process of manufacturing flexible abrasive web material which comprises feeding a plurality of thin carded fibrous membranes onto a moving endless support, adding a flexibilizing agent to the deposited membranes to render them pliable in use, applying abrasive grain to the deposited flexibilized fibrous membranes, alternating the deposition of additional fibrous membranes and abrasive grain until the web has been built up to the desired thickness, applying suitable adhesive binder and compacting the web.

4. The process of manufacturing flexible abrasive web material which comprises feeding a plurality of thin carded fibrous membranes onto a moving endless support, adding a flexibilizing agent to the deposited flexibilized fibrous membranes, alternating the deposition of additional fibrous membranes and abrasive grain until the web has been built up to the desired thickness, impregnating the fibers of the lastly deposited membranes constituting the upper portion of the fibrous web with an embrittling agent to render the fibers friable in use, applying suitable adhesive binder and compacting the web.

5. The process of manufacturing flexible abrasive web material which comprises forming a fibrous base from a plurality of superimposed thin carded fibrous membranes, and introducing

abrasive grain and adhesive binder internally of the fibrous web structure.

6. The method of manufacturing flexible abrasive articles which comprises incorporating abrasive grain and a suitable adhesive binder internally of a preformed web of uncompacted fibrous material and compacting said web to the desired density.

7. A process of making flexible abrasive web material which comprises forming a fibrous base from a plurality of superimposed thin carded fibrous membranes, rendering those membranes forming the lower portion of said web structure flexible by the addition of a flexibilizing agent to the membranes during the deposition, impregnating the fibers of the uppermost membranes with an embrittling agent to render them friable in use, introducing abrasive grain and a suitable adhesive binder internally of the web, and compacting the web to the desired density.

8. The method of making a flexible fibrous abrasive web which comprises forming an abrasive-containing web according to the method of claim 1, and applying a final coating of abrasive grains and adhesive binder to the outer surface of said fibrous web.

9. A process of making flexible abrasive web material which comprises feeding a plurality of thin carded fibrous membranes onto a moving endless support, applying abrasive grain to the deposited fibrous membranes, alternating the deposition of additional fibrous membranes and abrasive grain until the web has been built up to the desired thickness, progressively increasing the amount of abrasive grain applied between successive membranes whereby the resulting fibrous web has an abrasive grain content progressively greater from one surface of the web to the opposing web surface, applying a suitable adhesive binder and compacting the web.

RAYMOND C. BENNER.
ROMIE L. MELTON.