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[54] **ABRASIVE FOAM LAMINATE**

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[51] **Int. Cl.** **B24d 11/00**

[58] **Field of Search** 51/401, 402, 404, 407, 295, 51/296, 297, 298, 298.1, 299, 299.1

[56] **References Cited**

UNITED STATES PATENTS

2,284,716	6/1942	Benner et al.	51/394 X
2,327,199	8/1943	Loeffler	51/404 X
3,252,775	5/1966	Tocci-Guilbert	51/296

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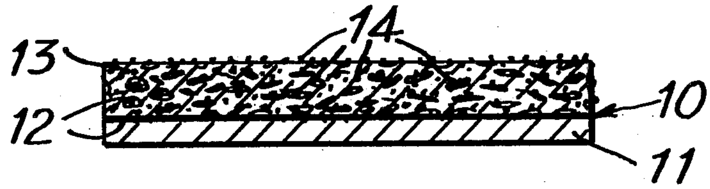
[57] **ABSTRACT**

A high density abrasive-containing foam product is made by impregnating a low density foam with a slurry of adhesive and abrasive, drying the same below the cure temperature of the adhesive and then laminating the dried and impregnated foam to a reinforcing backing by heat and pressure which both densifies the foam and effects the lamination using the abrasive binder adhesive to effect adhesion between the foam component and the backing component.

3 Claims, 3 Drawing Figures



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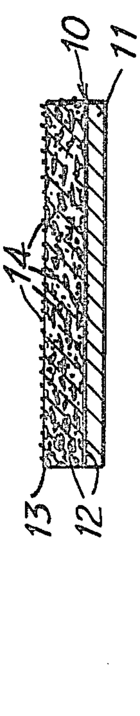

FIG. 1

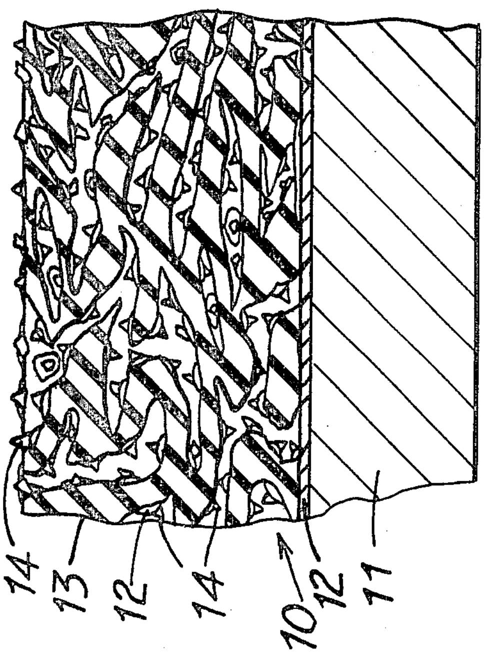

FIG. 2

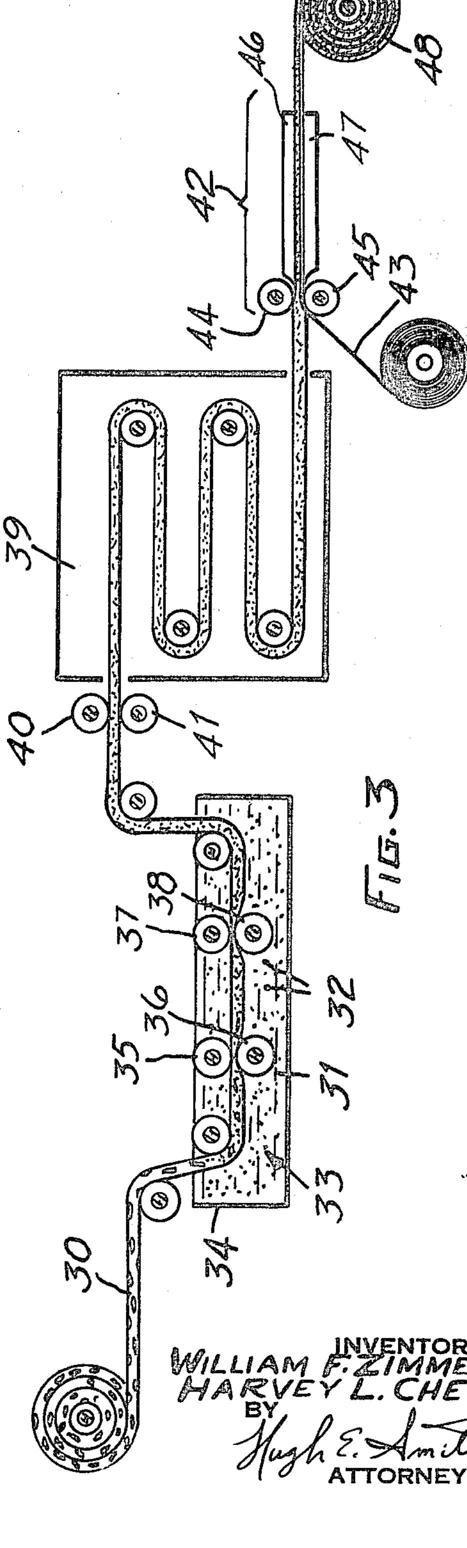

FIG. 3

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ABRASIVE FOAM LAMINATE

BACKGROUND OF THE INVENTION:

1. Field

This invention deals with the production of an abrasive material wherein a flexible backing is provided to support a plurality of abrasive grains adhesively bonded therein. It further relates to the fine abrasive end of such field wherein finish of the workpiece abraded constitutes one of the important criteria for the performance of the abrasive material. The terms "buffing" and "polishing," while generally synonymous in common usage have definite and different meanings in the abrasive art. Buffing means the rearrangement of material on the surface of a workpiece, usually by friction, to produce a high finish. In contrast, polishing means the removal of material from a surface to correct minor surface imperfections. It is well accepted in the art that as the requirement for high finish goes up the ability to remove stock comes down. Therefore, the art has consistently used one type of relatively aggressive abrasive material for polishing and the desired stock removal and a different type of non-abrasive or only slightly abrasive material for buffing to a high finish.

2. Prior Art

Abrasive products made on resilient backings of various types have been proposed for many years. Most of these seem to have been the outgrowth of the use of sponge material for cleaning purposes and generally have fallen into three categories: (1) a foam or sponge having a coating of abrasive particles on the exterior thereof; (2) a sheet of coated abrasive laminated to a sponge or foam backing; and (3) abrasive grain incorporated in the foamable material prior to foaming with the resultant in situ production of a foam containing abrasive grain substantially uniformly distributed throughout. These products have never gained good commercial acceptance except for some minor successes as kitchen scouring aids. Industrially, the best performing product for polishing purposes has not been a sponge or foam-backed material but rather one in which a layer of cork particles provided the resilient support required to obtain a reasonably good finish while the abrasive grain coated on the surface thereof gave a reasonable amount of stock removal. None of these prior art products have given satisfactory combined finish levels and stock removal rates to satisfy the needs of industry. Laminates of particulate bonded foam material and associated flexible reinforcing backing are disclosed and claimed in the copending application of George L. Haywood, Ser. No. 638,042, filed May 12, 1967, now U.S. Pat. No. 3,607,159. The present invention constitutes an improvement in the method of forming products of the general type disclosed in the aforementioned Haywood application and particularly relates to the formation of such products from an open celled or reticulate foam material in which the abrasive grain distribution is reasonably uniform throughout. Accordingly, it is the object of this invention to provide a method for producing an abrasive material which gives superior finish and superior stock removal at one and the same time. It is a further object of the invention to provide a resilient foam-containing material of this type which is capable of withstanding the rigorous operating conditions which have heretofore kept foam-backed abrasive products in the kitchen and out of industrial plant use to any extent.

SUMMARY

In general, the present invention provides a resilient abrasive product having a high density (10 to 30 pounds per cubic foot) open cell foam uniformly impregnated with an adhesively bonded abrasive grain content and adhered to a flexible reinforcing backing member. The process involved in making this product includes the steps of impregnating a low density (2 to 6 pounds per cubic foot) open, interconnected cell foam material with a slurry of abrasive and binder adhesive utilizing alternate applications of compressive force and release thereof to the foam to cause the slurry to thoroughly penetrate, followed by a drying of the impregnated foam at a temperature below the curing temperature of the binder adhesive to permit retention of the porous structure of the foam, and a subsequent densification-lamination step to increase the density of the foam and to firmly adhesively bond the same to a flexible reinforcing backing.

DRAWINGS

FIG. 1 is a cross-sectional view of the material produced by the present invention.

FIG. 2 is an enlarged, schematic representation of a portion of the cross-section of the material of FIG. 1.

FIG. 3 is a schematic illustration of the process used to produce the material of the present invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

More specifically, and referring now to the drawings, FIG. 1 illustrates the general appearance of the improved abrasive material of the present invention. The material **10** comprises a flexible reinforcing and supporting member **11** which may be paper, cloth, film, fibre or any of the backing materials conventionally used for coated abrasive manufacture. Superposed on and sharing an interface with said backing **11** to which it is adhered is a resilient structure **13** having a controlled density, compressibility and pore size as is more fully described below. Disposed on and preferably within the surface of structure **13** is a plurality of abrasive grains **14** bonded to structure **13** by an adhesive **12**. Unseen in the scale of the drawing of FIG. **1**, but shown clearly in the enlarged schematic view of FIG. **2**, is the adhesion of structure **13** to backing **11** by the same adhesive **12** which serves to bind the abrasive grains to the external and internal surfaces of structure **13**.

The resilient structure 13 may be formed of any solvent-resistant, durable organic open cell or reticulated foam or foam-like material having a finished density of from 10 to 30 pounds per cubic foot, a 25 percent compression deflection value as measured by ASTM 1961 1147–62T (Test For Compressibility And Recovery Of Gaskets) in the 10 to 30 pounds per square inch range, a porosity of from 55 to 85 percent and an average pore or interstice opening diameter at the surface of from 0.006 to 0.020 inch. Such a pore size amounts to a count of from about 80 to 150 openings per linear inch. In the preferred embodiment the finished density ranges from 14 to 16 pounds per cubic foot and the pore size is the equivalent of 100 plus or minus 10 openings per linear inch. While the thickness of the finished resilient structure may vary substantially dependent upon the use of the resultant abrasive product, it is preferably one-fourth inch or less in thickness with the optimum being about one-sixteenth inch thickness.

As indicated above, the finished density of the foam structure is required to be in the range of 10 to 30 pounds per cubic foot with definite porosity requirements. Generally, it can be stated that open cell or reticulated foams of this high density are not readily available commercially — most of the commercial foams of this type ranging from 2 to 6 pounds per cubic foot which are far too soft and compressible for our purposes. Where available on an experimental basis, it has been found that the pore size of such high density foams is far too small to permit their use in the production of the desired product of this invention. Typical open, interconnected cell polyurethane foams are well known as, for example, described in U.S. Pat. No. 2,961,710. Accordingly, the present invention is concerned in part with the process whereby the desired final or finished high density foam structure is obtained from a starting material of much lower density as is described in detail below.

As previously indicated, the flexible backing member may be any of the conventional, readily available flexible backings known to the coated abrasive art. While conventional coated abrasive cloth backings are preferred, due to the ease with which they may be joined in the fabrication of belts, etc., it is possible to use many types of filamentary or fibrous materials such as papers, vulcanized fibres, films, foils, thin metal backings and the like as the end application use may dictate.

The resilient structure is bonded to the backing member through reactivation of the abrasive binder adhesive as described below. Preferably, the binder adhesive is solvent-resistant in order to prevent delamination when the product is used in "wet" grinding operations. Adhesion of the foam to the backing must be sufficient to withstand the shock, shear stress and abrasion encountered during use and should generally be in excess of 4.0 pounds per inch as measured by ASTM (1964) D–1876, T-Peel Test, or at least in excess of the value at which the foam cohesively fails when the foam-to-backing adhesion is measured by such test.

Since the primary usage of this material is in a combined polishing and buffing type operation, the abrasive grain is preferably on the fine side ranging from grit 220 down to grit 400 or finer. The type of abrasive grain does not appear critical and any of the abrasive material such as silicon carbide, aluminum oxide, garnet, flint, diamond, emery and the like or mixtures thereof conventionally used in the coated abrasive art may be used in the present product as desired.

In contrast to conventional coated abrasives where an extremely hard, rigid binder is desired, the grit binder for use on this polishing and buffing material must be at least semi-flexible when cured and dried to its final stage. The adhesive should not be highly cohesive in the sense that it forms a film over the pores of the resilient structure. These pores must be left substantially open in the finished product. Generally, the grid binder is solvent resistant and the use of drying oil-modified phenolic, acrylic or epoxy resins is preferred. The adhesive grit binder is not applied in a separate layer as with conventional coated abrasives but is used to form a slurry with the abrasive grain and the mixture of grain and adhesive is applied by the process described below.

Referring now to FIG. 3 of the drawings, the starting point of the production of the abrasive article of the present invention is the provision of a sheet **30** (preferably in continuous form) of a low density, resilient, highly porous, open celled or reticulate foam material. Such foams may have an initial density of from 2 to 6 pounds per cubic foot and an initial porosity of 80 percent or more (by 80 percent porosity is meant that 80 percent of the volume of the specimen is void and only 20 percent is solid material. The porosity is determined by comparing the apparent volume of a specimen, i.e., its weight in air divided by its measured geometric volume, with its actual volume, i.e., that volume actually occupied by the solid parts of the structure). Preferably, the material is a polyester or polyether type polyurethane foam. Other foams such as open cell rubber or vinyl foams can be used if desired. The low density foam sheet 30 is passed into impregnating contact with a slurry **33** formed of adhesive **31** and abrasive grain **32**, e.g., by immersion, as shown at **34**. While contact is maintained between the foam sheet **30** and slurry **33**, the foam sheet **30** is repeatedly pressed or squeezed as by rollers **35–36** and **37–38** with alternate release of pressure between squeezings as shown schematically in the drawing. This creates a pumping action whereby the slurry **33** is uniformly dispersed throughout the open cell structure of foam sheet **30**. With proper control of viscosity, simple immersion in the slurry may be adequate in some instances but the alternate application and release of pressure is a preferred step. From the impregnating zone **34**, the wet foam sheet **30** now containing a fairly uniform coating of adhesive **31** and abrasive grain **32** on all of its exterior and interior surfaces (as is more clearly seen in FIG. **2**) passes to a drying zone **39**. Preferably, the sheet **30** has excess slurry wiped from its external surfaces by wipers **40–41** as it passes to zone **39**. Zone **39** must be maintained at a temperature below the cure temperature of the binder adhesive **31** and the drying cycle should be sufficiently long to permit most of the solvent to escape from the binder adhesive and for the adhesive to dry to a nontacky state. These conditions will obviously vary depending upon the choice of binder adhesive but it has been found that provision of a dwell time in zone 39 of 24 hours at ambient room temperature is generally adequate. From zone **39**, the dried and impregnated sheet **30** now moves to a laminating zone **42** wherein it is mated with a supporting backing **43** of the type previously described. Rolls **44–45** are heated and generate the requisite curing temperature in sheet **30** to cure the adhesive binder **31** to an insoluble state. The spacing or gap-setting of rolls **44–45** is such as to compress sheet **30** to the desired final thickness, e.g., one-sixteenth inch. This combination of heat and pressure causes the adhesive **31**, which is on the interface surface of member **30** next to backing **43**, to adhere to backing **43** and to effectively laminate sheet **30** to backing **43**. As shown, heated platens **46–47** may be provided, if necessary, to hold the temperature and pressure of sheet **30** at the required cure and laminating level until completion.

The resiliency of the finished product is at least 8 percent and preferably 9 percent or more as measured by ASTM D–1564–R, Resilience (Ball Rebound) Test. The deposited grain weight from slurry 33 is preferably about 6 pounds per sandpaper ream when using 400 grit silicon carbide, although grain weights as low as 2–3 pounds per sandpaper ream or as high as 9–10 pounds per sandpaper ream may be used if desired.

Following cure and lamination to the backing, the laminated product **30–43** is wound into rolls **48** for storage and is then ready for fabrication into belts, sheets, discs, rolls or other conventional forms.

The following specific example is illustrative of the preferred embodiment of the invention:

A 60 yard roll of 6 inch wide, three-fourths inch thick commercial polyurethane open cell foam (poly-type) having a density of 2 pounds per cubic foot and an initial porosity of 80 percent is fed through a slurry consisting of:

Acrylic latex (49% total solids)	– 30.3% by weight
Methyl cellulose (4% aqueous)	– 6.0% by weight
400 grit silicon carbide abrasive grain	– 45.5% by weight
Distilled water	– 18.2% by weight

The foam material is alternately subjected to squeezing and release during its passage through the slurry (4 cycles) with a pick up of 1,000 percent of its initial weight. The wet foam then passes through a pair of wipers which remove excess surface slurry and then is passed into a drying zone maintained at room temperature for a period of 18 hours. Upon removal from the zone the foam will be non-tacky to the touch and weighs about 600 percent of the initial foam weight. The height or thickness of the foam was only slightly reduced. The dried and impregnated foam material was then combined with a standard waterproof coated abrasive cloth backing material using heated rolls set to a 0.080 inch gap in conjunction with spaced heated platens (same gap setting). The temperature of the rolls and platens was held at 315° F. and the heating time of the laminate was 10 minutes. Upon removal from the laminating zone the product was air cooled to room temperature and wound into a jumbo storage roll. A number of discs were then cut from this material and used to polish the surface of acrylic test pieces. The resulting finish was excellent and showed none of the scratch pattern normal with a coated abrasive polishing belt.

A similar run was made in batch fashion using the same slurry as previously mentioned (made by adding the methyl cellulose to the acrylic latex with stirring to give a uniform blend followed by addition of the grain with rapid stirring and finally the addition of the water after the grain had been completely dispersed to give a uniform slurry). In this instance, a hard sheet of foam 6½ inch × 4 inch × ¾ inch was used. The foam was 2 pounds per cubic inch polyurethane open cell foam. By hand squeezing, the foam was impregnated with the slurry, wiped off and allowed to dry for 24 hours at room temperature. The dried and impregnated foam was then combined with a standard waterproof coated abrasive cloth backing in a heated press. The pressure was about 100 p.s.i. and the laminate was compressed to a total thickness of 0.08 inch. The temperature of the press was 315° F. and the dwell time slightly over 10 minutes. The finished product was used as a hard sheet to polish oak floor tiles and was found to be superior to standard products in the finish produced.

The present invention permits the relatively uniform incorporation of abrasive grain within a foam structure of ultimate high density to provide a resilient, porous media which is supported by a reinforcing backing. The product density and dimensions are controlled by the application of pressure after impregnation and drying. Pressure without permitting the drying would cause the pores to be closed and would not produce the desired product. By virtue of this process, no separate laminating adhesive is required to bond the impregnated foam to the reinforcing support backing but the grit binder serves a dual purpose in this regard.

We claim:

1. An improved abrasive article which comprises an initially low density open cell foam sheet having a pore structure throughout of sufficient size to accommodate abrasive grains; abrasive grains positioned within said pore structure and bonded therein by an adhesive; said low density foam sheet containing said abrasive grains substantially uniformly distributed throughout said pore structure being compressed to a substantially higher than initial density and a flexible reinforcing backing bonded to such compressed foam sheet.

2. An article as in claim 1 wherein said densities range from 2 to 6 pounds per cubic foot for the initial low density up to 10 to 30 pounds per cubic foot for said higher density.

3. An article as in claim 1 wherein said foam sheet is bonded to said reinforcing backing by the same adhesive used to bond the abrasive grain to said foam sheet.

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