

Jan. 22, 1946.

N. P. ROBIE ET AL

2,393,267

METHOD OF MAKING LAMINATED ABRASIVE ARTICLES

Filed June 27, 1944

Fig. 1.

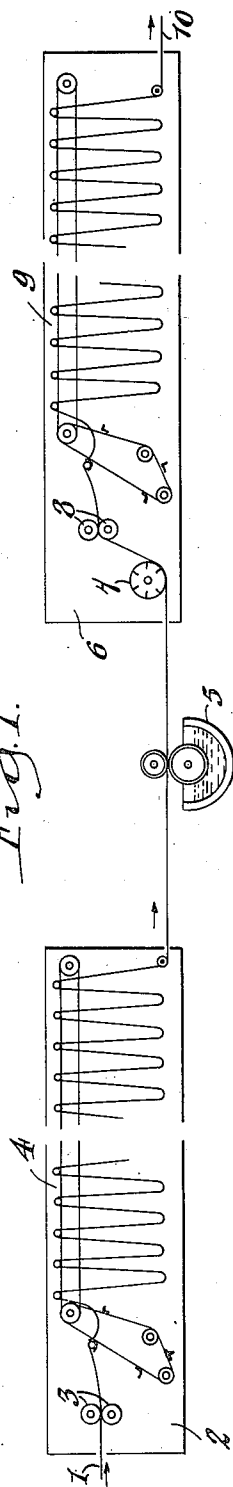


Fig. 2

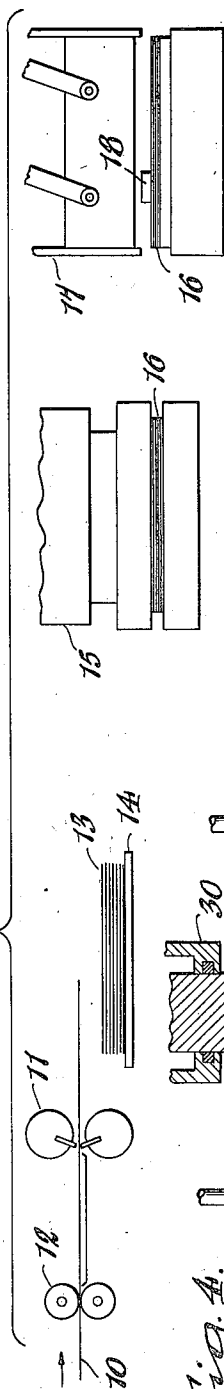


Fig. 4.

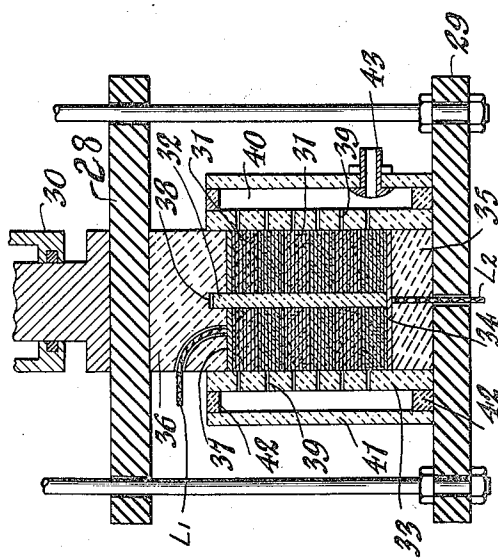
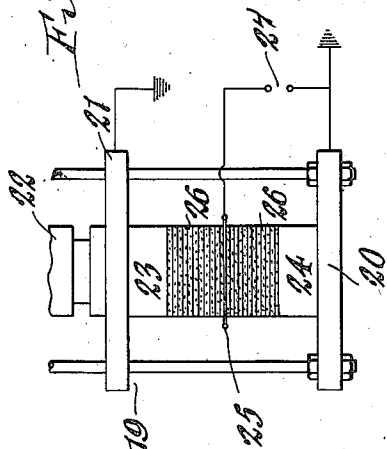


Fig. 3.



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METHOD OF MAKING LAMINATED
ABRASIVE ARTICLES

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Application June 27, 1944, Serial No. 542,327

7 Claims. (Cl. 51—297)

This invention relates to a method of making abrasive articles. More particularly it relates to a method of making abrasive articles composed of a plurality of layers of web material having abrasive particles included therein, coated on one face or both faces thereof, or both, in which such layers of web material are secured together by cured adhesive material.

One of the objects of the invention is the provision of a fast efficient method of producing abrasive articles made of such adhesively secured laminae of web material. Another object is the production of such abrasive articles wherein the adhesive is hardened to the optimum degree without damaging the fibres of the web material due to prolonged heating. A further object is the production of such abrasive articles having more uniform properties throughout their extent than it is possible to obtain by practice of prior art methods. These and further objects will appear in the following description.

One type of article produced by the method of the present invention is that disclosed and claimed in the application of Melton et al., Ser. No. 408,936, filed August 30, 1941. Abrasive articles of this type consist of a plurality of layers of thin felted abrasive containing webs superimposed one on the other, said layers being adhesively united over certain portions of their contacting surfaces or over the whole of such surfaces. The abrasive containing fibrous web material used in making the product in accordance with the present invention may be made in several ways. One method is that described in Patent No. 2,284,716, issued June 2, 1942, wherein a plurality of thin carded fibrous membranes are imposed upon each other to build up a web of loosely felted fibrous material on a traveling support. Abrasive grain is fed onto the fibrous membranes in various stages of the building up of the final web, so that abrasive grain is distributed through such web. Thereafter the web is sized with a suitable adhesive such as glue, thermoplastic resins, thermosetting resins, latex, and synthetic rubberlike materials, and the web is then compacted to final thickness, after which the sizing adhesive is dried.

Various other methods may be employed to form such web with included abrasive. Other such methods are those disclosed in application Serial No. 375,517, filed January 22, 1941, and in Patent No. 2,284,739, issued June 2, 1942. Any of the abrasive materials in common use may be employed, such as silicon carbide, diamonds, boron carbide, fused aluminum oxide, flint, co-

rundum, emery, rouge, and similar substances. The size of the abrasive particles employed depends upon the use to which the final abrasive product is to be put and may vary from the finest polishing or buffing powders to the coarser grit sizes used in grinding.

Although the present invention will be described in connection with abrasive articles formed from the above fibrous webs with included abrasive, it is to be understood that it displays similar advantages in making laminated abrasive products wherein the laminations are composed of webs of other material, such as paper fibers, having abrasive particles included therein, and that it may be practiced with webs of various materials such as cloth, paper and felted fibrous webs such as those above having abrasive particles only on the surface or surfaces thereof.

In the prior art, laminated abrasive products such as those made by the present invention have been produced by superimposing a plurality of layers of abrasive coated or abrasive included sized webs, with or without additional coatings of additional adhesive in the form of a liquid film or as an impregnated sheet material, between the adjacent layers of the superimposed webs to act as a bonding agent. Such additional adhesives may be glue, natural or synthetic resins, rubber, latex, sodium silicate, shellac and the like. Such layers, which may have been cut to finished size before the laminating step are then subjected to a cold pressing operation to cause a preliminary adhesion between the layers, so as to permit handling of the resulting article. Following such cold pressing the article is heated in a hot press, the platens of which are heated either by steam or by electric resistance heating. With wheels of any appreciable thickness, such as $\frac{1}{4}$ inch or more, a considerable length of time in the hot press must be provided, particularly if such products are stacked between platens as is necessary in production methods. Extended heating in the hot press is necessary because of the low heat conductivity of the laminated material, even when compacted by being subjected to pressure in the order of 1000 pounds per square inch. Usually from $1\frac{1}{2}$ to 2 hours in a hot press is required when the articles are stacked, such time being determined by the time it takes the center products in the stack to reach the highest temperature which they could attain. If only a single article is hot pressed at one time, press time is determined by the time it takes the center portion of the ar-

ticle to reach such temperature. Such hot pressing operation accomplishes a partial curing of the sizing adhesive and of the added laminating layers of adhesive, if such are used, and compacts the articles to their final density. It is necessary, however, to follow the hot pressing treatment with an extended heating in a oven in order to complete the cure of such adhesives.

The above method is open to the serious objections that since the heating in the hot press is accomplished almost solely by conduction of heat from the platens through the material from the end surfaces of the article or the stack of articles, a relatively long time in the press is necessary to bring the center of the article or stack to the required temperature. This results in the subjection of the relatively delicate fibers of the articles particularly in those portions in contact with or adjacent the platens to a high temperature for a long period, and results in weakening them. Furthermore, the sizing and laminating adhesives in the articles in portions which were in contact or near the press platens are much more fully cured than those in those portions distant from the platens. Thus any particular article so treated is not uniform in properties throughout its extent, and, if the articles are hot pressed in a stack, such articles are not uniform in properties from article to article, even after the final oven cure. The necessity for oven cure of the articles made by hot pressing by prior art methods is also a disadvantage since it adds to the time necessary to make the articles. Furthermore, the initial cost of the oven is considerable, and the cost of its operation and maintenance of such oven is substantial.

The method of the present invention overcomes the disadvantages inherent in the prior method involving the hot pressing of laminated abrasive products of the type described. The invention consists broadly in the subjection of laminated abrasive containing or abrasive coated webs to the action of a high frequency electric field while the article is held under pressure. The electric field accomplishes the cure of sizing and laminating adhesives in a manner which is uniform throughout the extent of the article. Such method of heating is fast, and because all portions of the article are heated to the same degree and the material of which the article is composed is of poor heat conductivity, it is possible to complete the cure of the adhesive upon removal of the article from the high frequency electric field merely by the heat stored in the article, thus dispensing with the use of an oven.

The invention will be more fully understood by reference to the accompanying drawing in which:

Figure 1 is a diagrammatic view of apparatus for adjusting the humidity of sized abrasive containing webs, for adhesive coating the resulting web, and for drying the adhesive coating and bringing the adhesive coated web to a uniform humidity.

Figure 2 is a diagrammatic view of further apparatus employed in the manufacture of laminated abrasive products herein contemplated and includes a flying shear, a cold press for laminating cut portions of the web, and a beam press for dieing out the laminated sheet to size.

Figure 3 is a diagrammatic view of a press with high frequency electric heating means, and

Figure 4 is a view in cross-section of a modified press in which the laminated articles are subjected to a high frequency electric field.

It is to be understood that the apparatus shown

in the drawing described hereinafter is illustrative only of that used in a preferred mode of carrying out the method of the present invention, and that certain elements of the apparatus here shown may be modified or omitted altogether as will be indicated.

In the apparatus shown in Figure 1, a sized or adhesive impregnated abrasive containing web 1 is shown being fed in the direction of the arrow into a constant temperature, constant humidity, chamber 2 by means of feed rolls 3 which forward the web to a festooning apparatus shown generally at 4. Following the storage of the web material in chamber 2 for a sufficient length of time to dry the sizing or impregnating adhesive if it was not already dry and to bring it to a uniform humidity throughout its extent, it is then fed out to adhesive applying device 5, which applies a uniform coating of an additional laminating adhesive of the type above indicated, to the bottom face of the web. The thus coated web is then fed into a second constant temperature constant humidity chamber 6 by vacuum roll 7 and cooperating feed rolls 8, which feed it to a festooning and storage device generally indicated by the reference character 9.

The purpose of storing the web material in the constant humidity chambers 2 and 6 is to assure that the moisture content of the laminated abrasive products subsequently to be treated in the high frequency electric press will be uniform. This is important since the heating effect of the high frequency electric field upon such articles depends upon their power factor, and the power factor of each article in turn depends upon its moisture content. Thus, if articles having different moisture contents are heated in multiple in the same high frequency electric field, those having the higher moisture content will be heated more highly than those with the lower moisture content, and the resulting articles will not be uniformly cured. The invention is not confined to the heating of such articles in multiple, however, since it is important that the articles have a definite fixed moisture content even though cured singly. The adjustment of the moisture content to such desired definite value allows curing to be affected in a definite reproducible manner, by consideration only of the mass of the articles to be cured at one time, by applying a high frequency field of known intensity to such article or articles for a predetermined period of time, said time having been arrived at experimentally in the previous curing of similar articles to the desired degree.

It is possible to dispense with the first humidity chamber 2, and to feed the air dried sized abrasive containing web directly to the adhesive coating means 5. In such case, humidity chamber 6 is relied upon to bring the adhesive coated web material to a constant moisture content. It has been found preferable, however, first to adjust such moisture content by means of chamber 2, then to apply a uniform coating of adhesive by means 5, and to accomplish merely the drying of such adhesive and such further adjustment of moisture content in the web as may be necessary, in chamber 6. By so doing there is assured a sized, adhesive coated, abrasive containing web, shown as issuing from the exit end of chamber 6, and designated 10 in Figure 1, which has a uniform moisture content throughout its thickness and extent.

It has been found that a temperature of from 75 90 to 95° F. and a relative humidity of from 50

to 60 percent in chambers 2 and 6 yield laminae of web material having a uniform moisture content of the desired amount. Such values may obviously be varied within limits as desired. It is to be understood that other methods than festooning the material in a chamber may be employed to bring it to the desired moisture content. It may, for instance, be treated in a roll to accomplish this result or it may be sheared into flat sheets and then subjected to an atmosphere of the requisite humidity. Constant moisture content throughout the laminated articles to be cured may also be substantially obtained by storage of the laminated cold pressed slabs of laminated web material, or the cold pressed uncured articles themselves, in a constant temperature constant humidity atmosphere for a long enough period. It is preferred, however, to obtain such object by bringing the laminae themselves to such condition of constant moisture content.

In Figure 2 web 10 is shown being fed to flying shear 11 by feed rolls 12. The processing which follows the discharge of the web 10 from chamber 6 should take place a relatively short time thereafter, or at least such length of time should be such that the moisture content of the web is not substantially changed. Sheared lengths 13 of the abrasive containing web fall upon table 14, upon which they are superimposed in the desired number that after being compacted it will yield a laminated slab of the desired thickness.

After a sufficient number of sheared lengths 13 have been assembled, the pile is introduced into a cold press 15 and subjected to sufficient pressure to cause them to adhere sufficiently together to enable the resulting slab 16 to be handled as a unit. Slab 16 is then introduced into a beam press 17, with which, by means of a clicker die 18, the operator cuts portions of the desired size and configuration from the slab. In the case of thinner articles, say $\frac{1}{4}$ " thick or less, slab 16 may be made of the final required thickness of the articles, and the articles cut therefrom in the beam press are thus ready for pressing, curing, and finishing. If thicker articles are desired, it is generally preferred to make them by assembling a plurality of layers of the slab material cut from slab 16, the confronting parts being coated with a suitable adhesive prior to their assembly, such cut slab portions then being cold pressed together.

Laminated articles of the desired thickness, assembled as above, are then heated under pressure in a high frequency electric field. This may be accomplished by a high frequency electric press shown generally as 19 in Figure 3. Such press consists generally of lower platen 20, upper platen 21, and a pressure applying means such as a pneumatic or hydraulic cylinder 22. In commercial production it is preferred to heat and press a plurality of articles at one time; for this purpose the arrangement shown in Figure 3 has provide suitable. The press frame, and upper and lower members 23 and 24, respectively, which contact the articles are made of metal, and, as shown, are connected to ground. Members 23 and 24, which constitute electrodes connected in parallel, are thus connected to the ground side of the high frequency electric source. Electrode 25, which may consist of a thin sheet of metal of good conductivity, shown as being placed between two thick laminated articles 26 which are to be heated and cured. Electrode 25 is con-

nected to the other of terminals 27, to which is connected a source of high frequency current (not shown). When a high frequency electric current is connected to electrodes 23 and 24 and to electrode 25, there is set up between electrode 23 and electrode 25, and between electrode 25 and electrode 24, a high frequency electric field of uniform strength throughout the space between them and thus throughout both articles being heated. Such high frequency electric field rapidly heats the sizing and laminating adhesives in the articles, causing them to reach curing temperature in a relatively short time, in the order of 5 to 10 minutes at most. The articles so heated are subjected to pressure to cause the layers to become firmly attached to each other, and by compaction of the web material to cause the article to reach the desired density. The pressure employed depends upon various factors, such as the density desired and the degree to which the web was compacted initially. In all cases, however, it is possible to attain a predetermined density of finished article with a much lower pressure, when the articles are heated by a high frequency electric field, than when the curing is performed by means of steam or electric resistance heated hot presses. This is due to the fact that the high frequency electric field heats the articles uniformly throughout their extent, thus causing them to exhibit more uniform plastic tendencies than they do in the conventional hot press. It is to be understood that more than two articles may be so heated, the number depending upon the size of the press, amount of power available from the high frequency source, and the thickness of the articles heated and cured.

A relatively short heating period in a press such as shown in Figure 3, for example 5 to 10 minutes, is sufficient to carry the cure of the adhesive or adhesives in the article forward enough so that the heat stored in the articles will, after their removal from the press, be sufficient to complete the cure. In the steam or electric resistance heated platen hot presses, on the other hand, the heating in the press of a comparable stack of similar articles requires from $1\frac{1}{2}$ -2 hours, and, as has been said, an oven cure is required after completion of the hot pressing operation.

Articles cured by a press such as shown in Figure 3 usually change somewhat, particularly in a direction parallel to the faces of the platens or electrodes, because of the slight flow of the material in that direction under heat and pressure. Where the articles are conventionally finished to final dimensions following cure and have the arbor hole, if the articles require it, punched through it later or have the arbor hole finished to final dimensions if it was punched through before curing, this is not objectionable. In cases where it is desired that the articles after curing shall require little or no finishing, it is preferred to use a press of the type shown in Figure 4.

Such press consists of upper and lower electrically insulating press platens 28 and 29, respectively, and a pressure applying cylinder 30 acting upon the upper platen. A plurality of laminated articles 31, having arbor holes punched therethrough, are assembled on an accurately fitting ceramic arbor 32. It is preferable to coat the arbor and the contacting faces of adjacent articles 31 with a parting composition such as talc, grease, or any other conventional parting materials employed in the molding of resins. The

thus assembled stack of articles 31 is then placed within a ceramic mold barrel 33 and on top of lower metal electrode 34, such lower electrode being fitted within the lower portion of barrel 33 on top of lower ceramic mold plunger 35, which likewise fits within the mold barrel. There is then inserted in the upper end of the mold barrel the upper ceramic mold plunger 36. Such plunger has the upper metal electrode 37 affixed to the bottom face thereof, and has a central aperture 38 for the reception of the upper end of arbor 32.

In order to provide for the escape of the volatile materials in the articles, particularly the adhesive solvents, upon heating and curing the articles, mold barrel 33 is provided with a plurality of small vents 39. These vents are shown much exaggerated in diameter in Figure 4 for the sake of clarity of illustration. A vacuum chamber 40, formed by cylindrical ceramic shell 41 and annular upper and lower sealing members 42, is formed about the mold barrel. Connection of such vacuum chamber to a vacuum pump (not shown) is effected by means of nipple 43 projecting from shell 41. Connection of the upper and lower metal electrodes to a source of high frequency alternating current is effected by means of electric cables L₁ and L₂ respectively.

Use of the apparatus shown in Figure 4 results in all the advantages described in connection with the apparatus in Figure 3, and in addition assures that the products will be accurate and uniform, both as to outer diameter and as to location and diameter of the arbor hole. Because of the relatively light pressure employed in the operation, it is feasible to make platens 28 and 29 of the non-metallic electrically insulating material shown. Metal platens may be employed, however, providing the top and bottom electrodes are well insulated from the press platens and frame.

For the purpose of illustration, the two following examples are given of methods by which the present invention may be carried out.

Example I

Unsize abrasive included web material is made in accordance with the above-mentioned Patent No. 2,284,716. The web is then rewound, sized with casein adhesive in a conventional paper and cloth coating machine, and stored in a constant temperature constant humidity chamber. After the adhesive is suitably dry and the material reaches a uniform moisture content throughout its extent, the wide roll is split to narrow rolls, and the smaller rolls sheared into sheets. Sufficient sheets are stacked to make a slab roughly 1/4 inch thick when hot pressed, and the sheets cold pressed together to form a slab. Discs are cut from the resulting slabs, the discs are adhesively coated, and are then cold pressed together to make preformed laminated wheels.

The resulting wheels are inserted, in a stack, between the platens of a press, with a flat copper electrode between the center articles in the stack. This electrode and the press (as the other electrode) are connected for 9 minutes to a radio frequency generator having an input of 4200 volts at 0.6 to 0.7 ampere, and with a frequency of 8 megacycles. Constant pressure is continually applied to the wheels, and at the end of 6 minutes the press is closed on the stops at around 500 lbs. per square inch pressure, which makes the thickness dimension 3 inches. At the end of approximately 9 minutes time the articles

reach a temperature of 300° F. throughout their extent and the power is turned off. Cure of the articles is completed in the open, after removal of the articles from the press, by the heat stored in such articles.

Example II

Fused alumina coated cloth, prepared by coating 80 mesh abrasive on one side of cloth drills by means of high grade glue, is coated on the non-abrasive side with 20 pounds per ream (480 sheet 9" x 11") of casein glue containing 1/3 solid glue dissolved in 2/3 water. The casein glue is known commercially as "Casco" glue. The casein glue coated abrasive cloth is then dried to a moisture content of approximately 7% in a constant temperature constant humidity chamber. Discs are cut from this sheet 3" in diameter with a 1/2" arbor. These discs are then stacked into a pile approximately 2 inches high, and the pile is placed between two insulated copper electrodes in a hydraulic press. High frequency currents are applied to the electrodes while subjecting the disc pile to a pressure 360 lbs. per square inch for a total time of approximately five minutes. Cure of the articles is completed in the open after removal of the article from the press, by the heat stored in them by the heating in the high frequency electric field.

Having thus fully disclosed our invention and the preferred modes by which it is carried out, we desire to claim as new the following:

1. The method of manufacturing laminated abrasive articles which comprises the steps of subjecting a web of material having abrasive grain affixed thereto in a constant temperature constant humidity atmosphere for a sufficient length of time to bring the material to the desired uniform moisture content throughout its extent, coating one face of the resulting web with a laminating coat of adhesive, again adjusting the moisture content of the web material by subjecting it in a constant temperature constant humidity atmosphere for a sufficient length of time to bring it to the desired moisture content, cutting blanks from the resulting web, superimposing such blanks, cold pressing such superimposed blanks to form a laminated article, and further pressing the article while subjecting it to the action of a high frequency electric field whereby the adhesive throughout its extent becomes cured to the desired degree.

2. The method of manufacturing laminated abrasive articles, which comprises the steps of storing a web of felted fibrous material having impregnating adhesive and abrasive grain included therein in a constant temperature constant humidity atmosphere for a sufficient length of time to bring the web material to the desired uniform moisture content throughout its extent, coating one face of the resulting web with a laminating coat of adhesive, again adjusting the moisture content of the web material by storing it in a constant temperature constant humidity atmosphere for a sufficient length of time to bring it to the desired moisture content, cutting blanks from the resulting web, superimposing such blanks, cold pressing such superimposed blanks to form an article, and further pressing the article while subjecting it to the action of a high frequency electric field, whereby both the sizing and the laminating adhesives are heated and cured to the desired extent.

3. In a method of making laminated abrasive articles from sheet material comprising abrasive

grain and a heat-softenable adhesive, the steps which comprise bringing each of a plurality of such sheets to the same uniform moisture content, superimposing such sheets, and pressing the assemblage of sheets so formed while subjecting it to the action of a high frequency electric field capable of uniformly heating the assemblage and for a sufficient length of time to soften the adhesive and bond the sheets together.

4. In a method of making laminated abrasive articles from sheet material having impregnating adhesive and abrasive grain included therein, the steps which comprise bringing each of a plurality of such sheets to the same uniform moisture content, superimposing such sheets, and pressing the assemblage of sheets so formed while subjecting it to the action of a high frequency electric field capable of uniformly heating the assemblage and for a sufficient length of time to soften the adhesive and bond the sheets together.

5. In a method of making laminated abrasive articles from sheet material having abrasive grain and a heat-softenable adhesive affixed to a surface thereof, the steps which comprise bringing each of a plurality of such sheets to the same uniform moisture content, superimposing such sheets, and pressing the assemblage of sheets so formed while subjecting it to the action of a high frequency electric field capable of uniformly heating the assemblage and for a sufficient length of time to soften the adhesive and bond the sheets together.

6. In a method of making laminated abrasive articles from felted fibrous sheet material having impregnating adhesive and abrasive grain included therein, the steps which comprise subjecting a plurality of such sheets to an atmosphere of controlled humidity for a sufficient length of time to bring the sheet material to a desired uniform moisture content, superimposing such sheets, and pressing the assemblage of sheets while subjecting it to the action of a high frequency electric field capable of uniformly heating the assemblage and for a sufficient length of time to soften the adhesive and bond the sheets together, whereby the adhesive becomes uniformly cured throughout.

7. In a method of making laminated abrasive articles from felted fibrous sheet material having impregnating adhesive and abrasive grain included therein, the steps which comprise subjecting a plurality of such sheets to an atmosphere having a temperature of about 90-95° F. and a relative humidity of about 50-60% for a sufficient length of time to bring the sheet material to a uniform moisture content, superimposing such sheets, and pressing the assemblage of sheets while subjecting it to the action of a high frequency electric field capable of uniformly heating the assemblage and for a sufficient length of time to soften the adhesive and bond the sheets together, whereby the adhesive becomes uniformly cured throughout.

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Certificate of Correction

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It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows: Column 5, line 31, after the word and period "throughout." and before the signatures, insert the following claims:

8. In a method of making laminated abrasive articles from felted fibrous sheet material having impregnating adhesive and abrasive grain included therein, the steps which comprise coating a number of such sheets with a laminating adhesive, subjecting a plurality of such sheets to an atmosphere of controlled humidity for a sufficient length of time to bring the sheet material and the laminating adhesive to a desired uniform moisture content, cold pressing an assemblage of a plurality of such sheets to form a slab, cutting an article from the resulting slab, and pressing the article while subjecting it to the use of a high frequency electric field capable of uniformly heating the assemblage and for a sufficient length of time to soften the adhesive and bond the sheets together, whereby the impregnating and the laminating adhesive are each heated and cured uniformly throughout.

9. In a method of making laminated abrasive articles from felted fibrous sheet material having impregnating adhesive and abrasive grain included therein, the steps which comprise coating a surface of the said sheet material with a laminating adhesive comprising a solution of casein, drying the coated sheet material to a moisture content of approximately 7%, assembling a plurality of such sheets in superimposed relationship, and pressing the assemblage while subjecting it to the action of a high frequency electric field capable of uniformly heating the assemblage and for a sufficient length of time to soften the adhesive and bond the sheets together.

in the heading to the printed specification, line 9, for "7 Claims" read *9 Claims*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 17th day of February, A. D. 1948.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.