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Helmick

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[54] METHOD OF FORMING FIBROUS BODIES WITH DISSIMILAR DENSITIES AND APPARATUS THEREFOR

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[52] **U.S. Cl.**.....**161/166,** 156/62.2, 156/369

[51] **Int. Cl.**.....**B32b 7/02**

[58] **Field of Search**.....156/622, 180, 181, 494, 376, 156/441; 161/166

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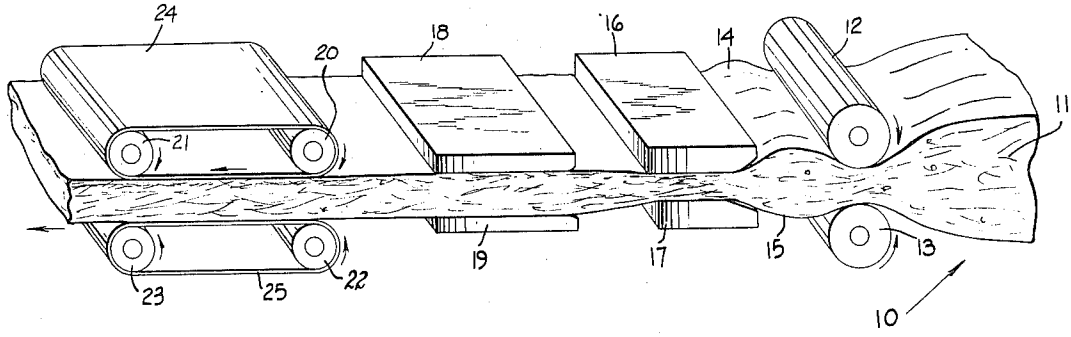
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[57] **ABSTRACT**

A continuous forming method, and apparatus therefor, of shaping, consolidating to dissimilar internal densities, and bonding, with low density loose mass of continuously intermeshed fiber containing thermosetting binder material throughout, comprising pulling such a body of fibers through a succession of compressing and heating operations to sequentially induce the desired dissimilar densities and commensurate therewith activating and curing the binder selectively within the designed areas of dissimilar density to permanently set the same, following an initial limited binder activation to effect coherency within the loose mass to endure the pulling through the compressing operations, and the dissimilarly densified and bonded product thereof.

9 Claims, 2 Drawing Figures



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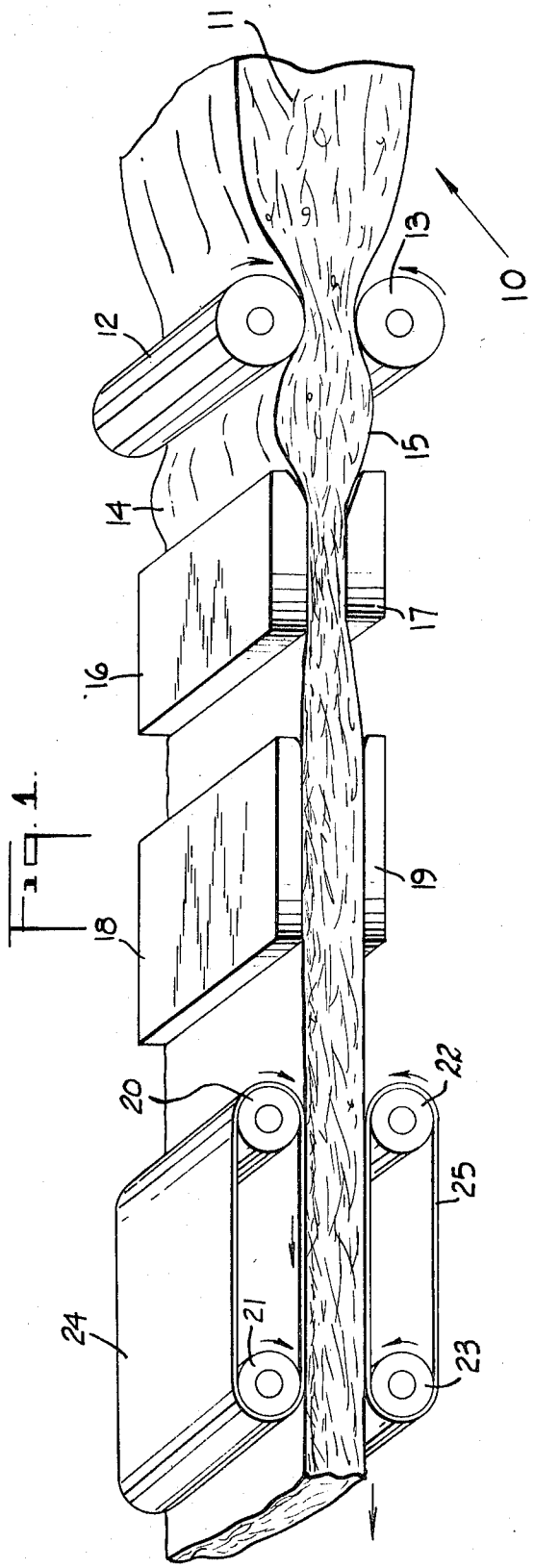


Fig. 1.

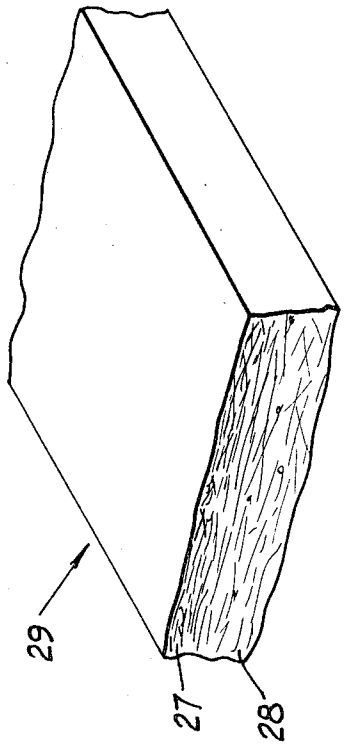


Fig. 2.

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METHOD OF FORMING FIBROUS BODIES WITH DISSIMILAR DENSITIES AND APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

The formation of relatively low density, bonded mineral fiber bodies with dissimilar internal densities has heretofore been generally attained by laminating and bonding two or more distinct bodies together, each being of a different mass density. One means therefor of the prior art comprises joining a body of intermeshed fibers previously bonded, and thus containing a set binder such as a heat activated and cured thermosetting resin which more or less has permanently fixed the fiber array and mass density thereof to that desired for the section provided by this component of the product, with a similar but distinct body also of intermeshed fibers containing as yet unset binder material throughout, compressing both bodies together, one superimposed upon the other, to effect the approximate density desired in the section provided by the body with uncured binder, and while so compressed, curing the uncured binder material contained in the one body which substantially permanently fixes the fiber array and mass density induced therein by the compression. Upon release of the compression applied to the composite of superimposed fibrous bodies following the curing of the binder in the one body, the intermeshed fibrous body containing the previously cured binder material and thus having had its fiber array and density fixed, being highly resilient due to its fibrous composition, returns to its original and previously fixed fiber array and density while the other intermeshed fibrous body containing the binder material subsequently cured during the compression of the combined bodies and thereafter fixing the fiber array, substantially retains the fiber array and mass density introduced and permanently fixed therein while under such compression. In such an operation, if the heat softenable binder content of the intermeshed fibrous body containing the uncured binder is ample it will often flow sufficiently, under the heat applied to set thermosetting materials, to contact or even enter into the adjacent intermeshed fibrous body with the previously cured binder to the extent of adequately uniting both of said distinct bodies together as a bonded composite during compression and the curing of the binder material within the one. Otherwise an additional adhesive material is applied intermediate the two fibrous bodies to achieve the union.

Such means necessarily employing the laminating of two or more distinct bodies of fiber, is more susceptible to delamination and often is inherently weaker than a product formed from a unitary mass of continuously intermeshed fibers. Or, if a substantial amount of ancillary intermediate binder is utilized therebetween to deter delamination and separation of the superimposed distinct bodies of fiber, it often introduces an intermediate stratum of a relatively higher degree of stiffness or lack of resiliency, and/or dissimilar consistency from that of the generally highly resilient fibrous bodies, which detracts from their desired physical properties. Additionally, the manufacture of fibrous products having dissimilar internal densities comprising the foregoing prior art means of joining two or more distinct fibrous bodies does not easily lend itself to continuous production procedures.

SUMMARY OF THE INVENTION

This invention comprises a sequence of distinct, successive operations of compressing and heating steps, and means to carry out the same, to shape, selectively consolidate to dissimilar densities, and permanently fix the introduced shape and dissimilar densities through controlled binder activation in a loose mass of continuously intermeshed fiber containing heat activatable binder material therethrough which is amenable to continuous manufacture including the substantial perpetual moving, that is, without interruption over prolonged production periods, of an endless body of binder containing intermeshed fiber as may be provided for example from a fiber forming production operation, through the series of operations in constant production of a completed fibrous product

having dissimilar internal densities. Moreover, the procedure and means of this invention, employing a substantially uniformly integrated mass of continuously intermeshed fiber, produces a product of dissimilar densities which possesses greater strength, resiliency and overall integrity, and very smooth surfaces, all with a minimum of binder content.

This invention is primarily directed to the manufacture of products of substantially any common glass fiber material and thermosetting resin binder, comprising conventional materials for the formation of relatively low density articles of exceptionally good thermal and sound insulating properties, for assorted uses or applications wherein such attributes are of significance in service, such as thermal or sound insulating panels, hot or cold air ducts, etc.

It is the primary objective of this invention to provide an improved manufacturing procedure and means for the formation of bonded fibrous bodies of dissimilar internal densities which is both more economical in production costs, and produces stronger and more effective products with smoother facing surfaces.

BRIEF DESCRIPTION OF THE DRAWINGS

This invention will be more fully understood and further objects and advantages thereof will become apparent when reference is made to the following detailed description of a preferred embodiment of the invention, and the accompanying drawings in which:

FIG. 1 is a perspective view schematically illustrating the procedural steps of the method of this invention, and apparatus thereof; and,

FIG. 2 is an end view in perspective of the fibrous product of dissimilar internal densities of the method of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The continuous forming method of this invention, including the shaping, consolidating to distinct internal sections or strata of dissimilar internal densities, and bonding, for low density loose masses of continuously intermeshed fibers containing heat activatable binder material throughout, comprises the steps of: first, imparting sufficient physical coherency to maintain the integrity of the unbonded loose mass of intermeshed fiber during subsequent manipulations by initially pressing the loose mass on two opposite faces to achieve good physical contact while heat activating and setting a limited portion of the binder material in the immediate area adjacent each of the pressed surfaces; second, introducing and fixing the desired density in a given area of the loose mass of intermeshed fibers by compressing said loose mass of intermeshed fibers on two opposite faces to such density and further heat setting the binder material contained in the area adjacent one surface of the two compressed opposing faces to extend the binder cure to the depth of the given area corresponding to the section for such density, and thereby permanently fix this density in said area; third, introducing and fixing another desired density in a remaining area of the loose mass of intermeshed fibers and completing the shaping and curing by again compressing the said mass of intermeshed fibers on the two opposite faces to the designed shape and to the desired density for the remainder of the intermeshed fibers of the mass containing the yet uncured binder material while applying heat to substantially set the remaining uncured binder material and thereby fix the overall shape of the body and desired density of the said remainder of intermeshed fiber, thus providing a shaped body with dissimilar internal bulk densities in adjoining sections or strata; and, fourth, applying a pulling force to the mass of intermeshed meshed fibers thus shaped and dissimilarly densified to draw the same in uninterrupted movement through each of the preceding steps.

The foregoing basic operations of this invention and preferred conditions therefor are described hereinafter in relation to the illustrated steps and means of the drawing and the disclosed manipulations. Referring to FIG. 1 of the draw-

ing, a generally endlessly supplied body **10**, comprising a loose mass of continuously intermeshed fibers **11** containing binder material throughout, as for example produced from a glass fiber forming production line wherein the binder material is typically introduced throughout the fibers in connection with their collection into a substantially homogeneous loose continuously intermeshed mass, is drawn by the pulling means subsequently described to move it substantially without interruption through the following successive forming operations. Preferably to attain maximum product uniformity and integrity, the body of fibers should comprise one continuous mass of substantially homogeneously intermeshed fibers as produced by the composite collection of substantially individual fibers and thus uniformly interspersed with and among each other as opposed to distinct layers of individual bodies of intermeshed fibers laminated together, although the manufacturing procedure of the invention can be practiced with a mass of fibers formed of a lamination of superimposed fibrous bodies, obtaining the advantages of the improved manufacturing method but foregoing certain advantages in the product characteristics as indicated above.

Body **10** of a loose mass of continuously intermeshed fibers **11**, containing throughout heat activatable binder material, is first drawn in continuous movement through a pair of heated and free rotating opposing rollers **12** and **13** which press the body of loose fibers on two opposing faces, typically constituting the two major surfaces of the blanket-like fibrous body, to achieve good contact and simultaneously therewith, heat the surface of each pressed face to achieve a degree of binder cure in the area immediately adjacent thereto. The degree of compression and heating is sufficient to advance cure the binder contained within the loose mass of fibers within the immediate area of the body surfaces **14** and **15** and set the same to the extent of imparting sufficient physical coherency to the loose mass of intermeshed fibers to adequately maintain its integrity in resisting being pulled apart, stretched or disrupted on being drawn through each of the subsequent forming manipulations, including the series of compressions, sliding contact with platens under pressure, and application of a pulling force ultimately upon the completed product to effect its movement through each of the preceding forming operations.

Thereafter, the moving body **10** of essentially yet loose intermeshed fibers is drawn in sliding contact intermediate an opposing pair of smooth faced platens **16** and **17** which are so spaced from each other as to compress the body **10** of loose fibers on its two opposite surfaces to consolidate the substantially loose intermeshed mass of fibers to approximately the density desired in a given section or stratum of a product, such as in the present illustration of the preferred embodiment of a sectional layer coextensive with the upper surface of the body **10**. While so consolidated, heat is applied to the one surface of the body which is adjacent to the section or stratum to be given the then induced degree of consolidation as a permanent density, and is effected by heating one of the opposing pair of platens, for example, as illustrated, the upper platen **16** is provided with heating means to heat the upper surface **14** of the body **10** and lower platen **17** is not heated. The quantity of thermal energy applied, controlled either through the degree of temperature or period of contact with the heated platen which of course is a function of the platen length and the rate of movement of the fibrous body, is adjusted to be such as to extend the depth of the area of binder cure to approximately that of the desired depth forming the area or stratum of the particular density thus imparted. As illustrated, the heated upper platen **16** achieves a cure of the heat activatable binder in the upper section or stratum of the body **10** fixing the compressed density therein while leaving the remainder of the binder within the fibers of the body uncured, whereupon following release of compression, the fibers in the area wherein the binder is yet uncured will resiliently return to a state approaching their original very low density and loose consistency.

Next the moving body **10** with partially cured binder and fixed density, is then drawn in sliding contact intermediate and compressed between a second opposing pair of smooth faced platens **18** and **19** spaced apart from each other a distance to compress the overall body to the approximate consolidation density desired in the remaining portion of the body **10** containing that section or stratum having the yet uncured binder material throughout. Both platens **18** and **19** are preferably provided with heating means, although only the platen adjacent the body of fiber containing yet uncured binder need be heated, and while the body **10** is passing therethrough it is heated sufficiently to substantially complete the cure of the remaining binder material thereby fixing the compressed density in that section or stratum which of course can, through adjustment of the spacing and thus the degree of compression effected by the respective pairs of platens **16** and **17** and **18** and **19**, be greater or lower than the density of the previously cured section or stratum of the body.

The smooth faces of the fixed immobile pressing platens and the sliding contact of moving fibrous body therewith additionally shape the body and exert an ironing-like effect upon its compressed surfaces to produce very smooth and plain finishes on each face.

Following the substantial completion of the shaping, consolidating to dissimilar internal densities, and bonding, a pulling force is continuously applied to the body **10** to draw it in uninterrupted movement through each of the aforedescribed forming operations, which is achievable without separation, stretching, disruption or other damage to the body due to the initial physical coherency provided therein by the preliminary brief surface area curing. Suitable pulling means for drawing the body comprises two pair of opposing pulleys, **20** and **21**, and **22** and **23**, each pair having extending therebetween belts **24** and **25**, respectively, lying in substantially parallel arrangement to each other and spaced apart from each other a distance somewhat less than the thickness of the cured but resilient body **10** of intermeshed fibers whereby the parallel moving belts **24** and **25** coact to frictionally grip the body **10** therebetween. At least one roll of each pair is provided with a suitable driving means, such as a motor, (not shown) to simultaneously move at substantially the same speed both belts in a complementing direction as shown by the arrows whereby the belts grip and pull the body **10** to effect an uninterrupted movement of the body **10** drawing the same through each preceding forming operation and providing for continuous production.

A typical product of this forming method is illustrated in FIG. **2** of the drawing comprising a shaped and consolidated panel-like article **26** of thermosetting resin bonded intermeshed glass fiber, having a section or stratum area adjacent one major surface previously consolidated to relatively high density as at **27** and the remainder of the article, comprising a generally coextensive section or stratum area, of low density as at **28**. Such a construction of dissimilar internal densities renders the product particularly suitable for the fabrication of air ducts by folding to a rectangular conduit or rolling into a tubular conduit with the high density and thus less porous surface positioned internally disposed for an air duct having a smooth high density interior surface which is effective in resisting erosion due to high velocity air traveling therethrough, and an outer surrounding area of very low density and in turn maximum thermal and sound insulating capacity.

A typical example of specific manufacturing procedure conditions for this invention comprises continuously drawing at a speed of about 9 ft. per minute, a blanket-like body measuring about 4 to 6 inches in thickness of a loose mass of intermeshed fibers containing approximately 15 percent by weight of the fiber of thermosetting phenolformaldehyde resin binder and of a loose bulk density of less than about one-half pound per cubic foot, thereby pulling it between a pair of rolls spaced about 1 inch apart with the upper roll heated to about 650° F. and the lower roll heated to about 500°–550° F. which effects a limited degree of binder cure just within the area of the sur-

faces so contacted and sufficient to introduce such coherency thereto to enable drawing the loose mass of intermeshed fibers through the subsequent compressing and heating applications. The continuously drawn body of fibers next is pulled between a pair of smooth surfaced opposing platens spaced three-eighths of an inch apart with the upper platen heated to 500°–550° F. and no heat in the lower platen whereby the contact time with the top platen measuring 1-½ ft. in length and at a moving speed for the fibrous body of 9 ft. per minute is about 10 seconds, and during this period the depths of the area of cure into the body of fiber extended about one-eighth inch through which section or stratum the binder was substantially completely cured fixing the density of such area. Thereafter the moving body of fiber is subsequently pulled through a second pair of smooth faced platens spaced apart 1 inch and each heated to 500°–550° F. wherein the cure of the remaining binder in the balance of the fiber is substantially completed. The product thus formed is of an overall thickness of about 1 inch with a high density section or stratum area adjacent the upper surface constituting a depth of about one-eighth inch of a density of about 3 to 3.5 pounds per cubic foot, and the remaining seven-eighths inch thickness of the product is comprised of a dissimilar density of about 1 pound per cubic foot. Both major surfaces of the product are very smooth and the surface of the high density section exhibits effective resistance and high velocity air impingement rendering the product eminently suitable for the fabrication of insulating air duct. Moreover, the product possesses sufficient integrity and resiliency to enable its wrapping around a 3-inch diameter mandrel without cracking or separation, enabling the formation of small diameter duct.

The instant invention is particularly directed to consolidating, shaping and curing resin binder containing fibrous felts comprising loose masses of intermeshed glass fibers having an original density ranging up to about 1 pound per cubic foot and containing dispersed throughout between about 3 and 25 percent of heat activatable resin binder materials such a phenolformaldehyde resin. Through the means of this invention, the mass of resin binder containing glass fibers can be shaped and consolidated by the foregoing compressing and heating steps into bodies of any dissimilar densities ranging from about one-half up to 8 or 10 pounds per cubic foot. And, through the introduction of additional like compressing and curing steps, products having three or more areas of sections or strata of dissimilar densities can be produced.

While this invention is particularly directed to and suitable for use with thermosetting resin binder containing masses of glass fiber, it is applicable to any binder and fiber admixture wherein the binder material is heat activatable and the fibers are of a high degree of resilience similar to that of common glass fibers and related synthetically produced mineral fibers typically of siliceous compositions whereby upon compression of the fibrous mass it will substantially return to its approximate original consistency unless fixed in its compressed condition through the curing of the binder. It is, therefore, within the scope of this invention to utilize any appropriate thermally activated binder and resilient fiber composition. Moreover, by changing the shape of the compressing and forming platens or dies, products of varying configurations can be produced with dissimilar internal densities by the same basic operations of this invention as set forth herein.

I claim:

1. Method of forming shaped and bonded intermeshed fibrous bodies having dissimilar internal density strata from loose resilient fibers and thermosetting binder comprising the successive operations of:

a. compressing and heating a moving mass of low density resilient fibers containing heat activatable thermosetting binder throughout by applying thereto a first compressive force and heating means on opposite faces of said loose mass;

b. then again compressing the mass of moving low density resilient fibers containing heat activatable thermosetting binder throughout by applying a second compressive force on the said opposite faces of the mass and further heating the surface area of one of said opposite faces while the mass is under compression to heat set the thermosetting binder within said area;

c. thereafter, again compressing the moving mass of resilient fibers to a dissimilar degree from that of the previous compressing by applying a third compressive force on the said opposite faces of the mass of fibers and simultaneously therewith heating at least the other compressed surface opposite the surface area previously cured while said mass is under compression to heat set the remaining thermosetting binder within said mass of fibers and;

d. drawing the foregoing mass of thermosetting binder containing resilient fibers through each of the preceding successive operations by applying a pulling force to the mass of resilient fibers containing thermoset binder as it emerges from the said compressing and heating operations.

2. The method of claim 1 wherein the moving bodies of low density mass of resilient fibers containing heat activatable thermosetting binder is a loose felt of bulk density less than about 1 lb. per cubic foot which is compressed and heated to consolidate and permanently fix the thermosetting binder containing mass of fibers at two dissimilar internal densities each within the range of approximately one-half to approximately 10 lbs. per cubic foot.

3. The method of claim 1 wherein the second and third compressing and heating steps are applied by passing the mass of resilient fibers in sliding contact between two pairs of opposed smooth-faced platens wherein at least one platen of each pair is heated.

4. Method of forming shaped and bonded intermeshed fibrous bodies having dissimilar internal densities strata from a loose mass of continuous intermeshed resilient fibers and thermosetting binder, comprising the distinct successive operations of:

a. compressing a moving loose mass of low density intermeshed resilient fibers containing heat activatable thermosetting binder throughout by applying thereto a first compressive force on opposite faces of the said loose mass and simultaneously therewith heating the surface of both said opposing faces while said loose mass is under compression to effect a consolidation of the loose mass of low density intermeshed resilient fibers and heat activation and set of the thermosetting binder contained in the surface area of the said opposed faces while the mass is compressed thereby imparting physical coherency to the moving mass of intermeshed resilient fibers;

b. then again compressing the now substantially physically coherent moving mass of low density intermeshed resilient fibers containing heat activatable thermosetting binder throughout and having the binder in the surface of the opposite faces substantially activated and set, by applying a second compressive force on the said opposite faces of the said loose mass and simultaneously therewith further heating the surface area of one of the said opposite faces while said loose mass is under compression to effect a further consolidation of the loose mass of low density intermeshed resilient fibers and activate and set the thermosetting binder an extended depth in to the surface area of the one face further heated, thereby permanently fixing the thus imparted consolidation density within said surface area;

c. thereafter again compressing the said moving mass of intermeshed resilient fibers having the density of the area adjacent one surface permanently fixed, by applying a third compressive force to a dissimilar degree from that of the previous compressing on the said opposite faces of the mass of fibers and simultaneously therewith heating at least the other surface area opposite the surface area of that previously cured while said mass is under compres-

sion to induce the desired final shape of the product and the density for the remaining portion of the intermeshed resilient fibers with the yet unactivated thermosetting binder and substantially complete the heat activation and set of the thermosetting binder therethrough thereby permanently fixing the shape and dissimilar densities of the formed fibrous body, and;

d. drawing the foregoing mass of thermosetting binder containing intermeshed resilient fibers through each of the preceding successive operations by applying a pulling force to the mass of intermeshed permanently fixed bonded fibers as it emerges from the said preceding compressing and heating operations to effect the said movement of said mass of intermeshed resilient fibers containing thermosetting binder through each of the preceding operations.

5. The method of claim 4 wherein the first compression and heating to impart the physical coherency to the mass of intermeshed resilient fibers is effected by a pair of spaced apart cooperating heated rollers and the following compressive forces are each applied by a pair of opposed smooth faced platens which apply an ironing effect producing smooth surfaces on both compressed faces of the product.

6. The method of claim 5 wherein the body of a loose mass of continuously intermeshed resilient fibers are glass fibers containing from about 3 to about 25 percent by weight thereof of thermosetting resin binder.

7. The method of claim 6 wherein the moving bodies of low density mass of continuously intermeshed glass fibers containing thermosetting binder is a loose felt of a bulk density of less than about 1 lb. per cubic foot which is compressed and heated to consolidate and permanently fix the thermosetting binder containing mass of glass fiber at two dissimilar internal densities each within the range of approximately one-half to approximately 10 lbs. per cubic foot.

8. The method claim 7 wherein the temperature applied throughout all compressing and forming steps to activate the cure of the thermosetting resin binder ranges between approximately 500° F. and approximately 650° F.

9. The low density bonded fibrous product of dissimilar internal densities of the method of claim 4.

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