United States Patent

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[54] **LAMINATION OF FLEXIBLE WEBS WITH FILAMENTARY ADHESIVE MATERIAL**
5 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **156/167,** 156/176, 156/178, 156/179, 156/291, 156/301, 156/324
[51] **Int. Cl.** **D04h 3/16**
[50] **Field of Search** 156/167, 176, 178, 179, 246, 229, 291, 299, 301, 324, 306; 161/140, 170

[56] **References Cited**
UNITED STATES PATENTS

3,239,992	3/1966	Hodgson	156/291 X
3,249,485	5/1966	Loew et al.	156/229 X

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Assistant Examiner—Stephen J. Lechert, Jr.
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ABSTRACT: The invention provides method and apparatus for applying molten adhesive, especially the "hot melt" type, to a flexible substrate with subsequent adhesive lamination of the substrate, by generating tacky fine filaments of the molten adhesive between a pair of moving surfaces, depositing the tacky filaments onto the flexible substrate while precluding contact between the substrate and the moving surfaces, then adhesively securing the substrate as a lamina to another lamina by means of the deposited tacky filaments.

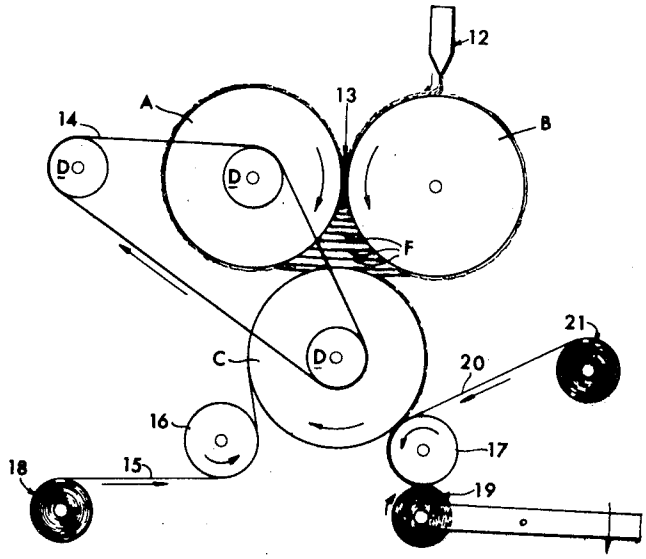


FIG. 1

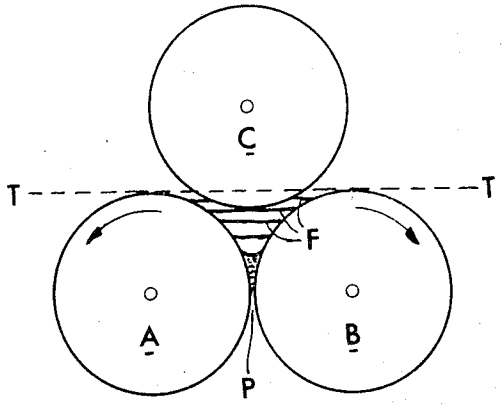
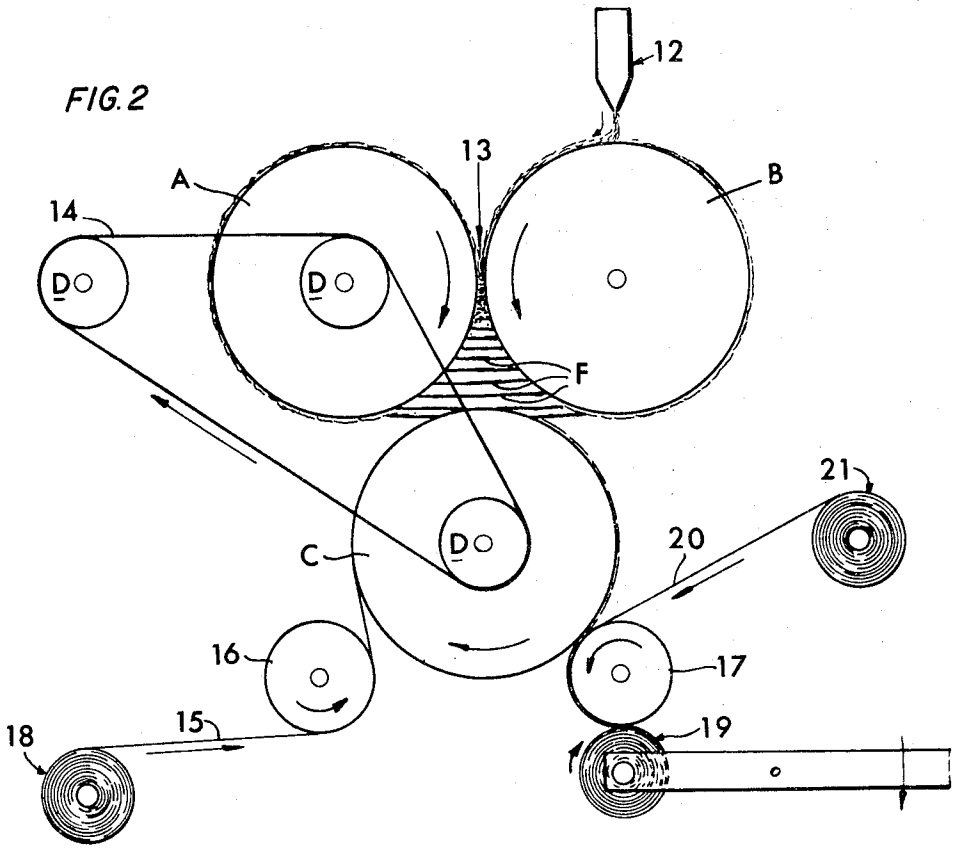


FIG. 2



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LAMINATION OF FLEXIBLE WEBS WITH FILAMENTARY ADHESIVE MATERIAL

This invention relates to methods and apparatus for applying adhesive to a substrate and more particularly to methods and apparatus for applying adhesive, in the form of fine filaments of softened thermoplastic material, to a flexible web, especially a fragile web, e.g. paper tissue, which is immediately secured by the adhesive to another web to form a laminated structure.

It is well known to use thermoplastic resinous materials as adhesives and also well known to form thermoplastic resinous materials into filaments or threads by spinning from solvent solutions of the materials or by dry spinning (extruding) the materials from the molten state. Both the foregoing spinning methods have been used extensively to prepare long continuous filaments. In U.S. Pat. No. 2,385,358 and Canadian Patent 454,159 of A. W. Hanson there are disclosed methods for preparing and recovering relatively short fine fibers which are drawn from a thin layer or film of fiber-forming material in the liquid or semiliquid state and caused to set or harden by treatment appropriate to the fiber-forming material, then collected or harvested for further processing by the usual drawing and spinning operations as employed with natural fibers.

The present invention is concerned with the formation of tacky short fine adhesive fibers or filaments of thermoplastic material by methods such as disclosed in the foregoing patents for fiber formation, and application of the filaments to a flexible substrate before they have set or hardened whereby the filaments can adhesively secure the substrate to another material to which it is laminated.

The invention thus comprises a process for adhesively securing a flexible web as a lamina to another flexible web with a thermoplastic resin adhesive which process comprises:

1. applying a coating of viscous liquid thermoplastic fiber-forming adhesive material to at least one of a pair of moving surfaces to establish between them a quantity of the material which is in contact with each of them,
2. continuously moving each of the surfaces in cyclic motion so that the segments of the surfaces, in contact with the material between the surfaces, are drawing away from one another, the speed of cyclic motion being sufficient to form fine tacky filaments of viscous liquid thermoplastic adhesive material between the segments as they separate,
3. passing a flexible continuous web in proximity to the material between the surfaces on a line which intercepts at least some of the filaments formed from the adhesive material so that tacky filaments are deposited on the web,
4. laminating a second flexible continuous web to the first web by passing them into contact with one another with the deposited adhesive filaments between them before the filaments can set or harden, and
5. setting the filaments to form an adhesive bond between the webs.

The invention further consists of apparatus for adhesively laminating a long flexible first web of material to a second long flexible web, comprising

a. a pair of counterrotating parallel rollers mounted to maintain, in a gap between them, a quantity of viscous liquid thermoplastic fiber-forming adhesive material,
b. a third rotating roll mounted parallel to the counterrotating rolls with its surface in proximity to the outside common tangent of the counterrotating rolls whereby it intercepts filaments of viscous liquid thermoplastic adhesive formed by counterrotation of the rollers with the adhesive between them,
c. means to feed the flexible first web lengthwise continuously over a segment of the curved surface of the third rotating roll where it intercepts filaments of adhesive, whereby the tacky filaments are deposited on the surface of the first web,
d. means to feed the second web continuously in laminar relation to the first web against the surface on which the filaments of adhesive are deposited while said filaments are still tacky, and
e. means to hold the two webs in laminar relation until the filaments have set to an adhesive bond.

The invention may be more readily understood from the following description of specific embodiments thereof and the accompanying drawings in which

FIG. 1 illustrates three rollers positioned to carry out the initial steps of the invention and

FIG. 2 illustrates diagrammatically an apparatus for carrying out the complete process of the invention.

In FIG. 1, A and B are two counterrotating rollers of substantially the same diameter mounted on parallel axes and having a coating of tacky viscous liquid thermoplastic material on the curved surfaces, said material forming a short bridge between the rollers at their point of closest proximity P. With the rollers rotating in the directions shown by the arrows, the tacky viscous liquid thermoplastic material adhering to the surfaces of both A and B is stretched as the surfaces of A and B draw apart in rotating past point P. Filaments F of viscous liquid thermoplastic are drawn out and are carried towards the line T—T which is the outside tangent common to the surfaces of the rollers A and B. Before the filaments reach the level of line T—T they intersect the surface of the roller C and are deposited thereon or on whatever is covering the bottom surface of roller C. Contact with the surface breaks the fine filaments and the greater part of the length of the filaments is deposited on or adheres to the surface of C, which can be moving. As rotation of rollers A and B continues the ends of the filaments adhering thereto move past the points of contact of the tangent T—T and are incorporated again into the coating of viscous liquid thermoplastic material on the roller surfaces. A suitable source of viscous liquid thermoplastic (not shown) supplies material to the surfaces of the rollers A and B to replace the material removed as filaments on roller C and maintains the bridge of material between rollers A and B. Roller C obviously must be placed by the outside common tangent of rollers A and B on the side where the curved surfaces of A and B are drawing away from one another, and for the directions of rotations shown on the drawing roller C must be placed above rollers A and B. If the directions of rotation of rollers A and B are reversed, roller C would then have to be positioned under rollers A and B in proximity to or intersecting their common tangent on the lower side to pick up filaments of thermoplastic material drawn out between the rollers A and B by their counterrotation

It should be noted that, although it is most frequently preferred to position roller C to intersect the outside common tangent as shown in FIG. 1, it is also possible to operate the process of the invention with the roller C in close proximity to this tangent without actually intersecting it. In such an arrangement the only filaments which are transferred to the surface of roller C from the zone of their formation between rollers A and B are those which break off from either or both rollers A and B and are carried by centrifugal force (and/or gravity when roller C is positioned below rollers A and B) into contact with the surface of C to which they then adhere. Obviously the centrifugal force impelling such filaments can be increased by increasing the speed of rotation of rollers A and B.

In FIG. 2, A and B are two counterrotating rollers with a thin coating of viscous liquid thermoplastic material, e.g. hot melt adhesive, on the curved surfaces thereof, applied from a source 12 and forming a bridge 13 between the rollers at their points of closest proximity. Roller C is positioned below rollers A and B and rotates as shown by the arrow, these three rollers being of substantially the same diameter and driven at substantially the same peripheral speed, as shown partially by drive wheels D and belt 14. A web of thin tissue paper 15 from a roll 18 is unwound and travels over a guide roll 16 and around over the top surface of roller C to intersect the common tangent line of rollers A and B then down into the nip between roller C and a laminator roll 17, thence to be wound up on windup roll 19. A second web of thin tissue paper 20 is

unwound from roll 21 and passes in the nip between roller C and laminator roll 17 where it comes in contact with web 15, is laminated thereto, and thence wound up therewith on windup roll 19. The hot melt adhesive from source 12 and on rollers A and B is a tacky viscous liquid thermoplastic material that is drawn from the bridge which it forms between rollers A and B as these rotate, and forms filaments F which contact the tissue web 15 as it passes over roller C; the filaments thereby adhere to the tissue web 15 and break off from the rollers A and B, forming fine lines of tacky adhesive on web 15 which is immediately laminated to web 20. It should be particularly noted that the filaments of the adhesive contact the tissue and are deposited thereon without there being any other contact between the tissue and the rollers or the coating of viscous liquid thermoplastic material thereon. It is essential to preclude direct contact between fragile tissue and the adhesive-coated rollers as the tissue would readily tear and become adhesively fastened to the adhesive on the rollers.

It appears probable that most thermoplastic materials which, by simple heating, can be liquified to form a tacky, viscous, liquid mass, can be drawn out in the tacky viscous liquid state to form fine filaments, although there may be some particular or specific conditions required by some such materials before they readily form such filaments. Obviously temperature is a factor which affects the formation of fine filaments of a thermoplastic, and a preferred temperature condition for formation of threads of any particular thermoplastic material in accordance with the present invention can be ascertained; such preferred temperature condition may be specific to the one particular material or to several or to many thermoplastic materials. Another factor which is found to affect the formation of filaments in the process of the present invention is the rate of shear which is applied to viscous liquid thermoplastic materials in drawing out filaments from a tacky mass; some materials are found to require higher rates of shear for the formation of fine filaments than do other tacky viscous materials. The rate of shear applied in drawing out fine filaments in accordance with the present invention is readily varied, for example, by varying the rate of rotation of rollers between which the filaments are formed and drawn.

It has been observed also that many thermoplastic materials can be converted to a viscous liquid mass suitable for use in the present invention by softening the material with a portion of one or more liquid solvents and/or plasticizers for the material which portion, on homogeneous mixing with the material, converts it to a tacky viscous liquid mass at ambient room temperature or higher but below the temperature at which the material normally softens to a viscous liquid state. The invention therefore includes the application of fine filaments of softened thermoplastic material from a viscous liquid mass regardless of whether the material has been softened to a viscous liquid mass only by heating or by admixture with solvent and/or plasticizer or by a combination of heating and admixture with solvent and/or plasticizer. It is apparent that when solvent and/or plasticizer is used to convert the material to a viscous liquid state, the solvent and/or plasticizer may or may not be a desirable ingredient in the filaments formed according to the invention and accordingly may or may not require subsequent removal to achieve setting of the filaments for formulation of adhesive bonds of adequate strength between laminae.

Examples of thermoplastic materials which have been found to be particularly suitable for formation of fine filaments of softened thermoplastic material in accordance with the present invention are (1) low molecular weight polyvinyl acetates, e.g. those made by the process disclosed in British patent specification 920,760; (2) low molecular weight polyethylenes, e.g. a polyethylene product having an average molecular weight around 2,000 sold under the name "Epolene N" (trademark); (3) copolymers of vinyl acetate and polyoxyalkylene compounds, e.g. copolymers of the type disclosed in British patent specification 874,130; (4) polycondensation products such as polyesters and polyamides, e.g. nylon; and (5) other polyolefins, e.g. polypropylene. Numerous other suitable thermoplastic material will be obvious to those skilled in the arts in which the filaments are to be utilized, the choice of the material most suitable for particular applications usually being governed by the combination of properties which it is desired to have in the filaments used in the applications.

Numerous embodiments of the method of the invention are contemplated, and these include for example the application of filaments of adhesive in the lamination of webs of delicate tissue paper to one another, as is illustrated in FIG. 2 of the drawings, the application of filaments of reinforcing fibers to a delicate substrate to impart structural (tensile) strength thereto as well as acting as adhesive in the lamination of the delicate substrate to a similar substrate, and the application of filaments of adhesive in the lamination of webs of delicate tissue to substrates of different material, e.g. woven or nonwoven textile fabrics.

EXAMPLE I

This example illustrates the application of fine filaments of a thermoplastic hot-melt adhesive material onto a delicate paper tissue web with subsequent lamination of a second web of paper tissue to the first, utilizing the method of the present invention in a manner similar to that shown in FIG. 2 of the drawing. The example was carried out with laboratory scale equipment which comprised a pair of counterrotating metal rollers each four inches (10 cm.) in diameter and three-quarters of an inch (12 mm.) wide, mounted on parallel axes with 0.25 mm. spacing between the circumferences of the rollers. Heating elements were mounted within these rollers to maintain them at a uniform elevated temperature (110° C.) while in use. A third roller about 5 inches (12.5 cm.) wide and 4 inches (10 cm.) in diameter was mounted above the foregoing rollers on a parallel axis so that its circumference cut through the top outside common tangent of the first rollers. A web of 4½ inch wide (123 cm.) single ply paper tissue having a basis weight between 10 and 11 pounds per 3,000 square foot ream, (i.e. between 16.4 and 17.9 grams per square meter, was mounted to travel from a supply roll, under the third roller in contact with the bottom part of the surface thereof where the latter traversed the common tangent of the heated rollers, through the nip between the third roller and a laminating roller where the web was laminated with a second web of the same type of paper tissue, and thence to a windup roll on which the laminated material was wound. The counterrotating rollers and third roller were driven uniformly at a speed of 200 r.p.m., and the tissue web travelling in contact with the third square meter), was at its peripheral speed thus moved at about 200 ft./min. (61 m./min.). A supply of a viscous liquid thermoplastic hot-melt adhesive was maintained on the circumferences of the counterrotating rollers to form a bridge across the gap between them, and as the rollers rotated, filaments of the adhesive were drawn from the melt in the bridge and rose towards the web passing under the third roller above and were deposited on the web as it moved across the outside common tangent line of the counterrotating rollers. The deposited filaments formed a faint track of adhesive, about the same width as that of the counterrotating rollers, along the length of the travelling web as filaments were deposited thereon; as the second web of tissue was laminated to the first web immediately after deposition of the filaments while the latter were still tacky, the filaments formed an adhesive bond between the webs which was found to be far stronger than the individual webs themselves. The width of the adhesively bonded area of the laminated tissue was that of the track of adhesive. The thermoplastic hot-melt adhesive used was a graft copolymer of vinyl acetate and polyoxyethylene, made, as described in British patent specification 920,760, by graft copolymerizing vinyl acetate onto a polyoxyethylene polymer sold under the name "Carbowax 4000" (trademark), the proportions of the vinyl acetate and polyoxyethylene in the

copolymer being in the ratio 85:15. The specific physical properties of this particular thermoplastic graft copolymer made it particularly suitable for use as an adhesive in laminating paper tissue in that the copolymer was completely water soluble or water dispersible; hence any laminated tissue web containing some proportion of the adhesive, on having to be scrapped for some reason during manufacture, did not have to be discarded because of its adhesive content but could be repulped in a beater, in which the adhesive would dissolve out in the water, and the repulped material could then be formed into a new web of paper tissue in the usual way. The proportion of adhesive applied to the tissue in this example was calculated by (1) cutting a large number of small uniform size samples of the laminated tissue both from areas which were free of adhesive and areas which were adhesively bonded, i.e. which were totally within the width of the track of adhesive, (2) weighing the samples, (3) averaging the weights of the adhesive-containing and adhesive-free samples, and (4) from the difference in the average weights of the samples, calculating the average weight of adhesive applied to the tissue along the width of the track of adhesive. By the foregoing measurements and calculation it was found that the amount of adhesive on the laminated tissue amounted to an average of about 17 percent by weight of the laminated tissue in the adhesively bonded area. From the foregoing figure and the known basis weight of the single tissue web, previously mentioned, it can be calculated that 1 pound (453 gm.) of the adhesive applied as a three-fourths inch (12 mm.) band would bond a length of 15,000 feet (4,580 meters) of tissue web. Despite the delicate nature and light weight of the paper tissue, the adhesive applied thereto in this example did not penetrate through the web, nor was it visible through the web, i.e. the adhesive did not "strike through" the web. Furthermore, from the feel of the laminated tissue it was not possible to detect, by hand, the location of the track of adhesive in the web, i.e. the bonded part of the tissue web had the same "feel" to the hand as the unbonded part because the small amount of adhesive did not noticeably or appreciably affect the flexibility, thickness, or drape of the tissue web. The substantial identity of the adhesively bonded laminate with the adhesive-free portion of the laminate with regard to feel, as described above, is particularly significant and advantageous for the utilization of the laminated webs in such applications as paper table napkins and facial and toilet tissue, where uniform thickness, feel, and flexibility are desired.

In view of the fact that the adhesive bond between the webs in the foregoing example was far stronger than the individual webs themselves, it is apparent that an adhesive bond of lesser strength, requiring only a smaller proportion of adhesive by weight of the webs being laminated, would be adequate for many if not all such laminations; thus in lieu of a proportion of 17 percent of adhesive, by weight of the web material in the bonded part of the web, a lower portion, e.g. 10 percent, 5 percent, or even less, appears to be suitable for many purposes. The proportion of adhesive applied to the web could be adjusted by various means, for example by increasing the temperature of the viscous liquid thermoplastic adhesive in the bridge of viscous liquid thermoplastic from which the filaments are formed, rendering it less viscous and making the filaments finer.

Inasmuch as a laminated structure comprising a fragile paper tissue lamina secured to another lamina with a adhesive, without the adhesive noticeably or appreciably affecting the feel of the laminated structure, appears to be a novel article of manufacture, the invention thus further consists of laminated structures comprising a lamina of paper tissue adhesively secured to another lamina by the process described in the foregoing and following examples. The invention further and more specifically consists of a laminated paper tissue structure consisting of at least two laminae of paper tissue adhesively secured to one another by the process described in the foregoing example.

EXAMPLE 2

In the manner described in the foregoing example, using the same weight of paper tissue, the same grade of thermoplastic hot-melt adhesive, and the equipment described above, a web of surgical gauze was laminated to a web of paper tissue to form a laminated web of gauze and paper tissue, the adhesive being applied to the paper tissue before lamination of the gauze thereto. The laminated product had the full tensile strength of the gauze and the full liquid absorbency of the paper tissue.

EXAMPLE 3

This example was carried out with the apparatus described in example 1, and with the same thermoplastic graft copolymer of vinyl acetate and polyoxyethylene being supplied to the counterrotating rollers which were at ambient room temperature instead of being heated as in example 1; the thermoplastic graft copolymer was softened by addition thereto of a small proportion of benzene (under 25 percent by weight of the copolymer) which converted the thermoplastic from a stiff rubbery solid at ambient room temperature to a mobile viscous liquid. The rotation of the counterrotating rollers drew filaments from the viscous liquid thermoplastic which filaments were deposited on a web of paper tissue moving under the third roller and formed a track of filaments along the length of the web as it moved under the third roller. The benzene content of the liquid thermoplastic was so low that it did not make any observable mark on the tissue web, and the track of thermoplastic formed an adhesive bond between the tissue web and a second web of tissue laminated therewith. Due to its volatility the benzene gradually evaporated from the filaments so that the bond they formed between the tissue webs eventually became as strong as the bond formed in example 1 by the same type of thermoplastic filaments formed from the thermoplastic at elevated temperature in the absence of any liquid softener.

Numerous modifications can be made within the scope of the invention, in varying from the specific embodiments described herein. For example, instead of being fed onto a pair of counterrotating rollers, the viscous liquid adhesive can be applied to a pair of continuous travelling belts whose paths of travel form the sides of a "V" at the bottom of which the liquid adhesive is maintained as a bridge from which filaments of adhesive are drawn as the adjacent surfaces of the belts travel upwards. Such an arrangement permits the accommodation in the open end of the "V" of a relatively long arcuate path of travel for a fragile web of tissue backed by a segment of a roller which intercepts the upward travel of the tacky filaments of adhesive formed between the travelling belts. Similarly, counterrotating rollers, e.g. A and B in FIGS. 1 and 2, may not both necessarily be of circular cross section. Thus roller A may have a cross section roughly rectilinear, e.g. triangular, square, hexagonal, with rounded corners and a radius of rotation approximately the same as the radius of the round roller it replaces. With such arrangement, bridging of the adhesive occurs only from the rounded corners of the roller A and filaments of adhesive are drawn out between the rollers only periodically during their rotation, instead of continuously. In this way a discontinuous track of adhesive filaments can be deposited along a continuous web moving in a path to intercept filaments formed between the rollers. Numerous other modifications and variations in the specific expedients described can be made without departing from the invention the scope of which is defined in the following claims.

What is claimed is:

1. A process for adhesively securing a flexible web as a lamina to another flexible web with a thermoplastic resin adhesive which process comprises:

i. applying a coating of viscous liquid thermoplastic fiber-forming adhesive material to at least one of a pair of moving surfaces to establish between them a quantity of the material which is in contact with each of them,

ii. continuously moving each of the surfaces in cyclic motion so that the segments of the surfaces, in contact with the material between the surfaces, are drawing away from one another, the speed of cyclic motion being sufficient to form fine tacky filaments of viscous liquid thermoplastic adhesive material between the segments as they separate,

iii. passing a flexible continuous web in proximity to the material between the surfaces on a line which intercepts at least some of the filaments formed from the adhesive material so that tacky filaments are deposited on the web,

iv. laminating a second flexible continuous web to the first web by passing them into contact with one another with the deposited adhesive filaments between them before the filaments can set or harden, and

v. setting the filaments to form an adhesive bond between the webs.

2. A process as claimed in claim 1 in which the viscous fiber-forming material is applied to a pair of counterrotating rollers between which tacky filaments of adhesive are drawn out as the rollers rotate.

3. A process as claimed in claim 2 in which the continuous web passes in a line which is in contact with a segment of the curved surface of a roller which intercepts tacky filaments formed by rotation of the counterrotating rollers.

4. A process as claimed in claim 3 in which the fiber-forming adhesive material is hot-melt adhesive maintained in a molten state on the counterrotating rollers by heating the rollers, and the filaments thereof are set to an adhesive bond by cooling to ambient room temperature.

5. A process as claimed in claim 4 in which the continuous webs which are adhesively laminated are both fragile paper tissue.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,629,027 Dated 21 December 1971

Inventor(s) Leo M. Germain, Shawinigan, Quebec, Canada

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 4, line 2, change "material" to --materials--

Column 4, line 51, change "square meter), was" to --roller--

Signed and sealed this 30th day of May 1972.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents

FORM PO-1050 (10-69)

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