Nov. 24, 1970 | I. W. FOX ET AL | 3,542,613

METHOD OF MAKING WOVEN PILE FABRIC CARPETS

Filed June 6, 1967

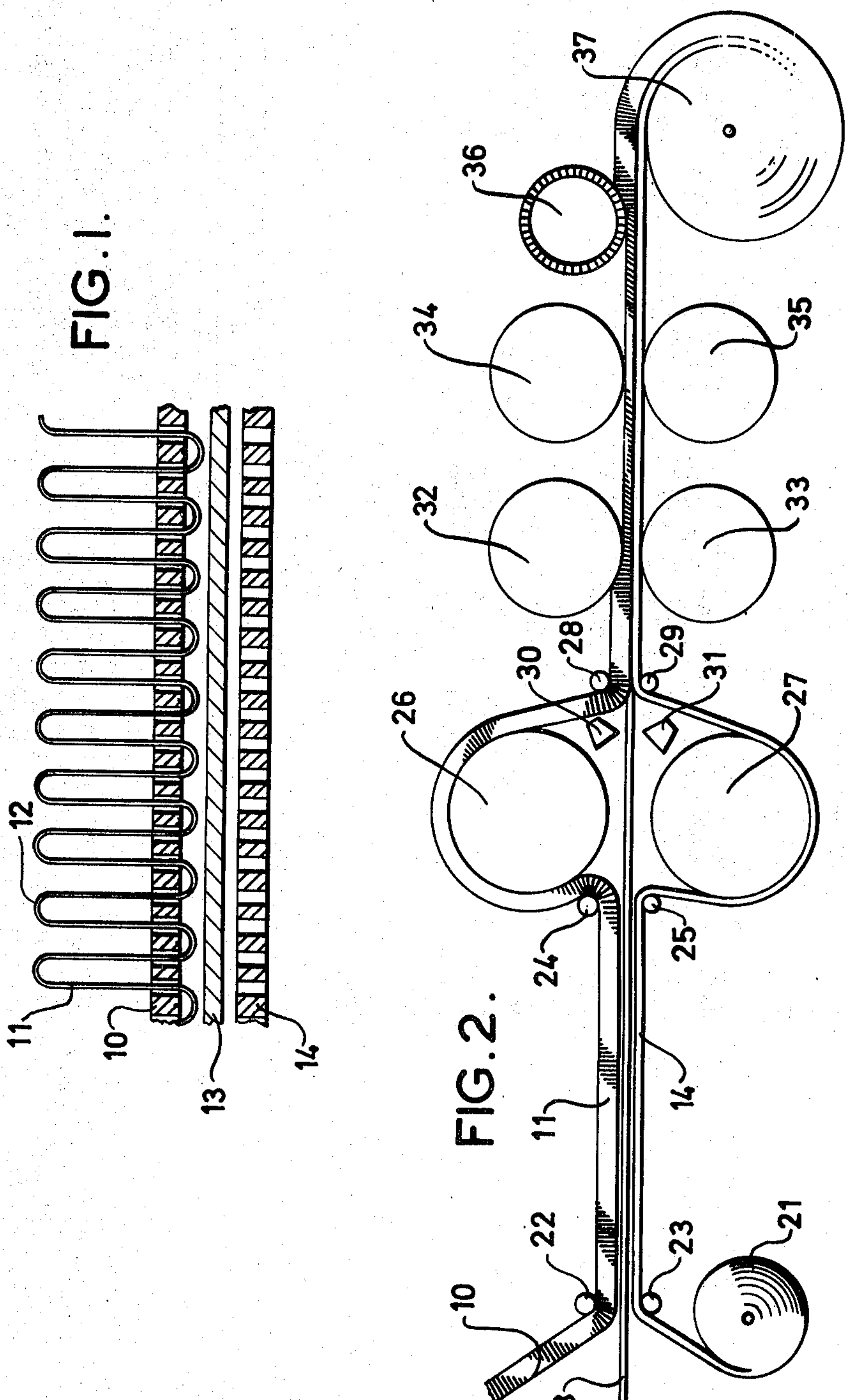

FIG. 1.

FIG. 2.

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United States Patent Office 3,542,613 Patented Nov. 24, 1970

3,542,613
METHOD OF MAKING WOVEN PILE FABRIC CARPETS

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Filed June 6, 1967, Ser. No. 644,008
Claims priority, application Canada, June 26, 1966, 963,919/66
Int. Cl. D03d *27/00;* D04h *1/74;* B32b *31/20*
U.S. Cl. 156—72 12 Claims

ABSTRACT OF THE DISCLOSURE

A method of making carpets comprises applying to the pile fibres non-permanently attached to the primary jute, a thermoplastic film, preferably a film of a thermoplastic rubber, in a heat softened but self supporting condition, and cooling the film in contact with both the pile fibres and the primary jute.

This invention relates to the bonding of organic fibres, both to each other and to substrates of different materials.

The invention has been developed primarily in connection with carpets, and will be particularly described with reference to the anchoring of pile fibres of a carpet to a fibrous backing material. It will be readily apparent however that the invention is of general application, and is not to be construed as limited to use in carpet manufacture.

In carpet manufacture, the pile fibres of the carpet are anchored by some means to a textile backing material, known as the primary jute, so called because it commonly comprises an open-weave jute fabric. In making a woven carpet, the primary jute itself is woven simultaneously with the application of the pile to the primary jute. The two operations are arranged in such a way that the pile fibres become physically attached to, or "tied into," the weave of the primary jute. In many cases with woven carpets this is all the anchorage of pile fibres to primary jute which is required, to provide a carpet of high physical strength and extended resistance to wear.

In most other forms of carpet, however, some additional means of anchoring the pile to the primary jute is required. For example, in the process of manufacturing the so called tufted carpets, the primary jute is pre-woven. Long pile fibres are woven through the open weave of the primary jute, one single continuous length of fibre constituting a complete row of pile in the finished carpet. The pile fibres are pulled tightly against one face (the under-side) of the primary jute, but are left as elongated loops extending from the other face (the top-side) of the primary jute. Whilst this process is simpler and less expensive than the method of making woven carpets, it is clear that some additional anchorage of the pile fibres to the primary jute must be provided, if the pile fibres are not to become disarranged.

Conventionally, an adhesive based on a rubber latex is applied to the under-side of the primary jute after the pile fibres have been woven into the primary jute. A further layer of material (known as the secondary jute or scrim) is applied to the latex-covered under-side of the primary jute. The scrim is usually a further layer of open-weave jute, similar to the primary jute. When the latex dries, it acts as an adhesive, anchoring the pile fibres to the primary jute, and the scrim to the pile fibres and the under-side of the primary jute. The scrim serves as extra protection of the pile fibre-primary jute bonds during subsequent use of the carpet, and improves the dimensional stability and "hand" of the carpet.

There are problems associated with the application of liquid adhesives however. For example, care must be taken to ensure that the liquid has sufficient penetration of the textile materials to cause satisfactory anchoring of the pile, and to cause locking of the pile fibres so as to minimise fiber losses on abrasion, but does not seep through to the top-side of the carpet to the extent that its presence spoils the appearance of the finished carpet. Liquid application is a dirty process, and requires extensive equipment, much of which is heavy and expensive. Due to the adhesive nature of the liquid which is being handled, regular and thorough cleaning and servicing of the equipment is necessary. Also, the rate of application is in many cases limited by the relatively slow drying speed of the latex-based adhesives at temperatures to which the carpet can be safely subjected.

To be suitable for carpet backing, latex-based adhesives themselves must meet certain requirements. In addition to their developing good adhesion on drying, they should be stable in liquid form to avoid serious problems during application, colorless and non-staining, so as not to spoil the appearance of the finished carpet. They should also impart good "hand" to the carpet, and have good ageing characteristics to prevent excessive wear, disintegration, etc. of the carpet over long periods of use. It is difficult to find a latex which meets all these requirements satisfactorily.

There has now been developed a new way of anchoring organic fibres to substrates, which finds especial use in carpet backing. This involves the use of a class of materials which have been found to be eminently suitable as carpet backing adhesives which can be used as thin films, and of a method of their application.

According to one aspect of the invention, there is provided a method of securing organic fibres to a fibrous substrate which comprises applying to the fibres and the substrate a thermoplastic self-supporting film in a heat softened but self-supporting condition, applying pressure to the film and the elements to be secured, and thereafter cooling the film in contact with the elements to be secured to effect bonding therebetween.

According to another aspect, there is provided apparatus for securing fibres to a fibrous substrate in a permanent manner by means of a self-supporting thermoplastic film, which comprises a heating zone, means for feeding the substrate carrying the fibres in a non-permanent manner to the heating zone, means for feeding the film to the heating zone, means within the heating zone for heating the film to a temperature at which the film softens but remains in a self-supporting condition, means within the heating zone for heating the substrate, and means for contacting the substrate, the fibres and the film whilst the film is in its softened condition.

The thermoplastic films which we have found to be eminently suitable for use in the invention are those which comprise thermoplastic rubbers. Such materials are generally compositions of block copolymers of an elastomer-forming monomer such as butadiene, isoprene and like conjugated diolefins, and a thermoplastic-forming monomer, e.g., styrene. Useful such materials are those based on three-block copolymers in which the center block is a thermoplastic polymer. Representative such materials are those of general form polystyrene - polybutadiene-polystyrene and polystyrene - polyisoprene - polystyrene. The center block may be made up of a random copolymer, e.g., of butadiene and styrene, provided that it is elastomeric in nature.

An especially useful thermoplastic rubber in accordance with the invention is a block copolymer of form polyisoprene-polybutadiene-polyisoprene which has been treated with a hydrohalogen, such as hydrogen chloride, under conditions such that only the polyisoprene blocks are hydrohalogenated. Such a preferentially hydrohalogenated block copolymer has the properties of a thermoplastic rubber, but also has the advantage of polar groups present in the molecule. This leads to improved penetration of the adhesive around the polar carpet fibres, and hence stronger adhesion.

Block copolymers having five or seven blocks in which each terminal block is a thermoplastic polymer and the blocks are in alternating sequence of thermoplastic and elastomeric polymers are also useful. These three-, five- and seven block polymers combine the properties of thermoplastics and elastomers. Thus they show high tensile strength and elongation at break in the "green" state, without any need for curing or vulcanization. They also show thermoplastic properties, being mouldable at elevated temperatures by conventional moulding and shaping processes, and retaining their moulded shape on cooling. The block copolymers having more than seven blocks are less useful as thermoplastic rubbers, as the materials then exhibit properties more like those of conventional random copolymers of two monomers.

The methods of preparation of the block copolymers are known, and do not form a part of the present invention. The usual method is by polymerization of the first monomer in solution using an anionic initiator such as butyl lithium. After substantially complete polymerization of the first monomer to form the first polymeric block, and without deactivating the polymer solution, the second monomer is added. This second monomer polymerizes onto the end of the pre-formed polymer, to make a two-block copolymer. After substantially complete polymerization of this second monomer, the third monomer is added to from a third polymer block. Step-wise-additions of monomers are made until a copolymer having the desired number of homopolymeric blocks has been formed. The block copolymer is then recovered from the solution and dried. When it is desired to produce a block copolymer in which one of the polymeric blocks is a random copolymer of two or more monomers, this block is formed by charging the monomers after only partial polymerization of the previous monomer charge.

Prior to preparing films from these block copolymers for use in the invention, it is preferred to compound the copolymers with a microcrystalline wax and a hydrocarbon resin. The wax serves to improve the flow of the film so as to ensure more efficient penetration of the film into the substrate-carrying fibres when the film is heated to its softened condition. The wax also reduces the tack of the copolymer at room temperature. Suitable microcrystalline waxes are the paraffin waxes, and may be used in an amount of from about 5 to about 45 parts by weight per 100 parts by weight of copolymer. The hydrocarbon resin has a beneficial effect on the adhesive properties of the copolymer when heated above its softening point. The resin is suitably used in amounts of from about 15 to about 75 parts by weight per 100 parts by weight of the copolymer. Suitable hydrocarbon resins are the derivatives of hydrogenated rosins, and terpene phenolic resins.

Films may be made from these block copolymers by a solution-casting method. In this method, the block copolymer after the required compounding is dispersed in a suitable solvent such as toluene, to make a fairly concentrated viscous solution. This solution is then spread out evenly onto a release surface by means of a doctor blade or similar device, at room temperature, and the solvent is allowed to evaporate. A film is then peeled away from the surface.

Alternatively, the films may be made by either of the processes known as chill roll casting and extrusion blowing. In chill roll casting, the polymer is fed into an Archimedian screw-type extruder, where the polymer is plasticized by the action of the screw. In its plasticized condition, the polymer is forced by the screw through a narrow slot die, from which it issues in thin film form. The film issues from the die at temperature of the order of 120° C., and is cooled by passing the film through the nip between a pair of chilled rollers. In extrusion blowing, the plasticized polymer is forced by an Archimedian screw through a ring die, the polymer normally moving in a vertical plane. Air is blown through the center of the die in the direction of travel of the polymer. The current of air serves to expand the polymer into a thin extruded film. The films are generally colorless, translucent or transparent materials.

The preferred block copolymers from which the films are made are of general form polystyrene-polybutadiene-polystyrene, and have a bound styrene content of from about 15 to about 45 weight percent, preferably from about 25 to about 35 weight percent. Films with a higher styrene content tend to suffer from the disadvantage that the films are stiffer and have less flexibility. One of their main advantages in carpet backing is then reduced. Films with a lower styrene content have low tensile strength, which may lead to problems in applying such films, and reduced adhesion when softened by heat. The molecular weight of the block copolymers is generally within the range 50,000 to 100,000 for optimum properties.

For use in the invention, the films suitably have a thickness of from about 5×10^{-3} inches to about 25×10^{-3} inches (5–25 mils), with the preferred range being from 55×10^{-3} inches to 15×10^{-3} inches (5–15 mils).

The following description of the method and apparatus of the present invention will have reference to the accompanying drawings, in which:

FIG. 1 is a diagrammatic cross-sectional view of a tufted carpet prepared in accordance with the present invention;

FIG. 2 is a diagrammatic cross-sectional view of an apparatus of the present invention.

In the drawings, like reference numerals indicate like parts.

Referring firstly to FIG. 1, the primary jute **10** is a piece of jute of open-weave form. The pile fibre **11** is woven through the primary jute **10**. The pile fibre **11** is pulled tightly against the under-side of the primary jute as shown, but is left loosely in the form of elongated loops **12** protruding from the top side of the primary jute **10**. These loops **12** constitute the pile of the finished carpet. As can be seen on the drawing, the pile fibre **11** is continuous and makes up all the loops in a single row of pile in the carpet.

There is applied to the under-side of the primary jute **10**, and hence also to the pile fibre **11** where it protrudes through to the under-side of the primary jute, a film **13** of a thermoplastic rubber. The film **13** is applied in a heat softened condition. At the same time a scrim **14** is applied to the under-side of the heat softened thermoplastic rubber film **13**. The film **13**, on cooling, effectively bonds together the pile fibre **11**, the primary jute **10** and the scrim **14**. Being of a rubbery material, the film **13** also imparts a degree of flexibility to the finished carpet, besides acting as a most effective adhesive.

Referring now to FIG. 2, the primary jute **10** carrying the pile fibres **11** is fed to the apparatus from a tufting machine, or from storage. The scrim **14** is stored in a roll **21**. The continuous lengths of primary jute **10** (under-side lowermost) and scrim **14** are led along converging paths by means of a pair of idler rollers **22** and **23**. The thermoplastic rubber film **13** is fed continuously between the pair of idler rollers **22** and **23**, so that it is disposed between the scrim **14** and the under-side of the primary jute **10**. The film **13**, primary jute **10** and scrim **14** are thus disposed along adjacent parallel paths, but are not at this stage in contact with one another.

The paths of the primary jute **10** and scrim **14** are directed by respective idler rollers **24** and **25** around respective steam-heated drums **26** and **27**. After passing around at least half of the cylindrical circumferential face of the respective drums **26** and **27**, the paths of the primary jute **10** and scrim **14** are led into contact in parallel relationship by means of respective vertically spaced idler rollers 28 and 29.

The thermoplastic rubber film 13 follows a path which is disposed between the paths of the primary jute 10 and the scrim 14. The path of the film 13 passes between, but does not touch the surface of, the steam-heated drums 26 and 27. The path also passes between a pair of radiant heaters 30 and 31, disposed adjacent to the drums 26 and 27.

In the vicinity of the pair of idler rollers 28 and 29, the paths of the primary jute 10, film 13 and scrim 14 converge so that the materials are brought into contact in the desired configuration. The material is then passed between a pair of heated pressure nip rollers 32 and 33, which form the required bond between the materials. The apparatus thus comprises a heating zone to which the materials are fed, the zone being bounded on the upstream side by the pair of idler rollers 24 and 25 and on the downstream side by the pair of heated nip rollers 32 and 33.

After passing between the nip rollers 32 and 33, the materials are fed between a pair of cold nip rollers 34 and 35 which exert further pressure and ensure completion of the bond between the materials. The materials are then subjected to the action of a pile beater roller 36, which is a counter-rotating brush covered roller arranged to brush the pile of finished carpet so that the loops 12 thereof stand up from the top surface of the primary jute 10. The carpet then passes to a wind-up 37 on which it is stored. The dimensions of the apparatus are approximately 15 feet in width and approximately 30 feet in length.

In operation, the primary jute 10 carrying the pile fibers, the film 13 and the scrim 14 are all fed at the same constant speed, which is of the order of 25 feet per minute. The drums 26 and 27, which have a diameter of approximately 3 feet, are heated by means of steam, their surface temperatures being between about 90° C. and 125° C. The temperature is readily maintained within these limits by using such steam-heated drums, thus avoiding the risk of damaging the pile of the carpet. The primary jute 10 and the scrim 14 are heated by contact with the surface of the drums 26 and 27 respectively.

The film 13 passes between the drums 26 and 27 and derives some heat by radiation therefrom. Further heating of the film 13 is provided by the radiant heaters 30 and 31, which are suitably directed onto the film. The film 13 is thus heated to its softening temperature and very quickly thereafter pressed into contact with the primary jute 10 carrying the fibres and the scrim 14 by means of the heated pressure rollers 32 and 33. A pressure of the order of 10 kilograms per linear inch is exerted between these rollers. The temperature of these rollers is maintained at or below 125° C. by steam-heating. These pressures and temperatures on the rollers 32 and 33 are preferably not exceeded, to avoid risk of damaging the pile fibres.

The extent to which the softened film penetrates the scrim 14 or the primary jute 10 can be regulated by adjusting the relative temperatures thereof, i.e., by adjusting the temperatures of drums 26 and 27. The higher the temperature, the greater the degree of penetration.

The materials are then subjected to further pressure between cold rollers 34 and 35. The pressure on these rollers is of the order of 25 kilograms per linear inch, which pressure can be safely used, as the rollers are not heated. These cold pressure rollers 35 and 34 effectively complete the bond between the materials. The disposition of the primary jute 10 above the film 13 and scrim 14 as shown in FIG. 2 is also helpful in assisting the strong adhesion bond between the materials.

As seen in FIG. 2, the apparatus is simple in construction. It can run for long periods of time without interruption. It does not have to handle liquid materials as components of the carpet, which reduces the servicing necessary, and obviates the need for extensive drying facilities. It has the advantage of compactness, relatively low power requirements and lightness as compared with conventional machines for applying latex backing to a carpet.

Many modifications may be made to the apparatus as illustrated without departing from the scope of the invention. For example, it may be found in some cases that radiant heaters for the film 13 are not necessary, the film deriving all the heat it requires from the drums 26 and 27. Further, the cold pressure rollers may be dispensed with in some cases, the heated pressure rollers themselves being satisfactory in completing the bond. It may be found necessary to provide some form of lateral guiding means for the apparatus to keep the materials on the pre-determined lateral path. Suitable guiding means, such as Foxwell guiders, are well known and readily available. As previously mentioned, the pile beater roller 36 may be replaced by a steam box through which the carpet passes, and which erects the pile by moisture expansion. In woven carpets, in which the pile is in the form of cut fibres instead of loops, a form of pile beater is not essential. The wind-up illustrated may if desired be supplemented by a conventional J-box, in which the finished carpet collects in folds.

In the apparatus illustrated, the drive may be supplied to the heated pressure rollers 32 and 33 and to the wind-up 37. It is sometimes advantageous to supply drive to the steam-heated drums 26 and 27 through the intermediary of a slipping clutch. Such an arrangement would reduce or eliminate any compression of the carpet by the drums 26 and 27 and the heated pressure rollers 32 and 33, due to irregularity in the drive units which might have a deleterious effect on the finished carpet.

In a further modification, a small amount of a latex adhesive may be used in addition to the thermoplastic film. The latex may be applied to the fibres and primary jute first, and then the thermoplastic film, in its heat softened condition, and the scrim applied as previously described. The latex may serve to hold the fibres more securely in position on the primary jute prior to the application of the thermoplastic film. Only a very small amount of latex is required. The adhesion is effected by a combination of the film and the latex.

In a further modification, it may be required to produce a carpet without a scrim. The apparatus illustrated could be modified to make such a carpet. The steam-heated drum 27 would be dispensed with, as would the heated pressure rollers 32 and 33. The bond would be completed between the primary jute 10 and the thermoplastic film 13 by means of cold pressure rollers.

In using the thermoplastic rubbers of the present invention to make a carpet without a scrim, it may be desired to emboss a pattern on the lower surface of the film. This may be done by using a lower cold pressure roller carrying an embossed pattern. Such an arrangement provides a carpet having the desirable property of resistance to slip when in use.

One of the significant advantages of the process of the invention is that the use of a film enables exact control of the weight of adhesive applied to a given area of carpet. Such control of the amount of liquid adhesive, whether it is a conventional latex or a hot melt applied in liquid form is not possible.

The following example illustrates the strength of a carpet produced using thermoplastic rubber films, in accordance with the invention.

A piece of tufted carpet was prepared according to the method of the present invention. Both the primary jute and the scrim consisted of open-weave jute. The primary jute was tufted in the normal way with woolen pile fibre.

A film was prepared of the following ingredients:

Block copolymer of general form polystyrene-polybutadiene-polystyrene, containing 30 weight percent of styrene, and having a molecular weight of approximately 60,000—100 parts by weight.

Microcrystalline paraffin wax—25 parts by weight.

Penta erythritol ester of hydrogenated rosin (hydrocarbon resin)—50 parts by weight.

The film was made by a solution casting method.

Both the primary jute and the scrim were heated prior to contacting them with the film in its heat softened condition. The materials were then subjected to heat and pressure to complete the bond therebetween. A two-inch strip of the carpet so prepared was then tested for peel strength.

The scrim and the primary jute were gripped between the jaws of a Scott tensile tester. The jaws were moved apart at the rate of two inches per minute, so as to peel the primary jute away from the scrim.

The carpet had a peel strength thus measured of 16–24 pounds per two-inch strip; which compares favorably with corresponding figures for latex-backed carpets.

In addition, the carpet so produced had good "hand," and the adhesive film had not deleteriously affected the appearance of the finished carpet in any way.

What is claimed is:

1. A method of making woven carpets which comprises applying the pile fibres to the primary jute of open weave form in a non-permanent manner and securing the pile fibres to the primary jute by contacting at a temperature of not more than 125° C. the fibres and the underside of the primary jute with a thermoplastic self-supporting film in a heat softened but self-supporting condition, said film comprising a thermoplastic rubber and being from about 5 to about 25 mils thick, and thereafter cooling the film in contact with the pile fibres and the primary jute to effect bonding therebetween.

2. A method as claimed in claim 1, wherein the primary jute carrying the pile fibres in a nonpermanent manner is heated at a temperature between 90° C. and 125° C. prior to contact with the film in its heat softened condition.

3. A method as claimed in claim 2 wherein a fibrous scrim is applied to the under-side of the film whilst the film is in its heat softened condition, and is secured thereto on cooling the film in contact with the primary jute, pile fibres and scrim.

4. A method as claimed in claim 3 wherein the primary jute and the scrim after contact with the film in its heat softened condition are subjected to pressure.

5. A method as claimed in claim 4 wherein the primary jute and the scrim after contact with the film in its heat softened condition are subjected to heat and pressure.

6. A method as claimed in claim 5 wherein the primary jute and the scrim are each heated prior to contact with the film in its heat softened condition, the temperature differential therebetween being adjusted to regulate the penetration of the film.

7. A method as claimed in claim 1 wherein the thermoplastic rubber comprises a block copolymer of an elastomer-forming monomer and a thermoplastic-forming monomer.

8. A method as claimed in claim 7 wherein the block copolymer is of general form polystyrene-polybutadiene-polystyrene or polystyrene-polyisoprene-polystyrene, the polystyrene comprising from 25 to 35 weight percent of the block copolymer.

9. A method as claimed in claim 8, wherein the block copolymer has a molecular weight of from 50,000 to 100,000, and the film has a thickness of from 5×10^{-3} to 15×10^{-3} inches.

10. A method as claimed in claim 7 wherein the thermoplastic rubber comprises a block copolymer having at least one terminal block of hydrohalogenated polyisoprene and a non-terminal block of polybutadiene.

11. A method as claimed in claim 7 wherein a small amount of a latex adhesive is applied to the fibres and the primary jute prior to the application of the thermoplastic rubber film.

12. A method as claimed in claim 1 wherein the film comprises a thermoplastic rubber, and the lower surface of the rubber comprises the lowermost surface of the finished carpet and has an embossed pattern thereon.

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HAROLD ANSHER, Primary Examiner

U.S. Cl. X.R.

156—306, 311, 321, 322, 435, 499, 583