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METHOD OF MAKING A DECORATIVE SURFACE COVERING

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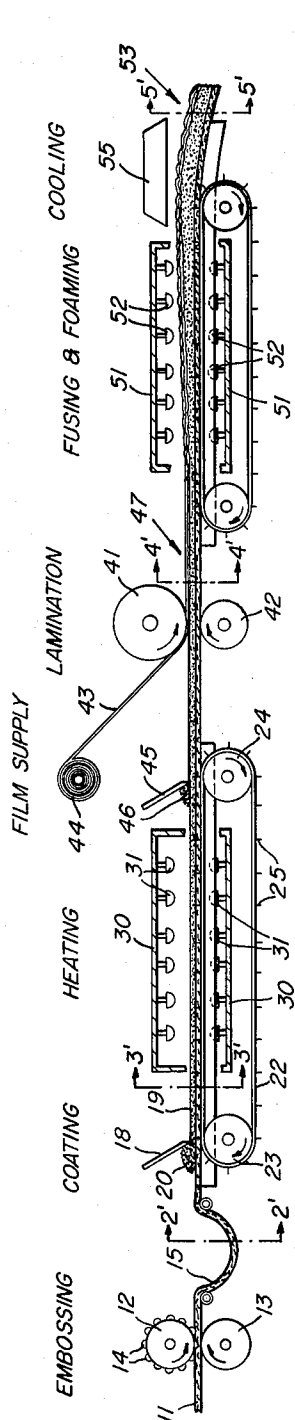


FIG. 1

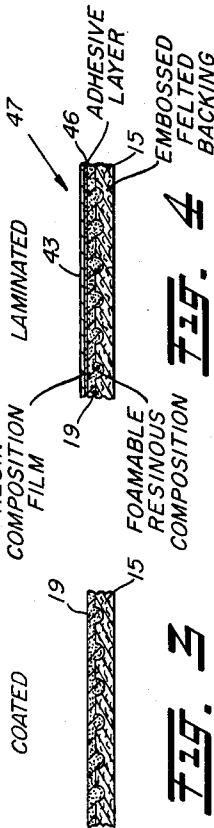


FIG. 2

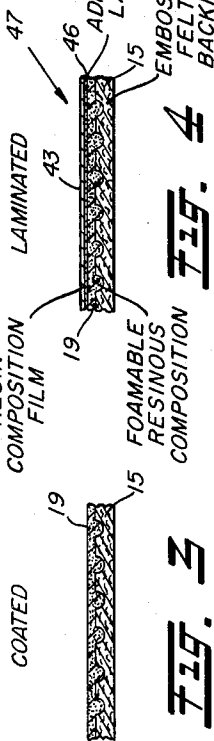


FIG. 3

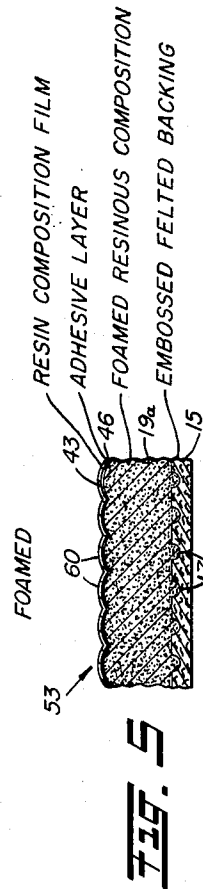


FIG. 4

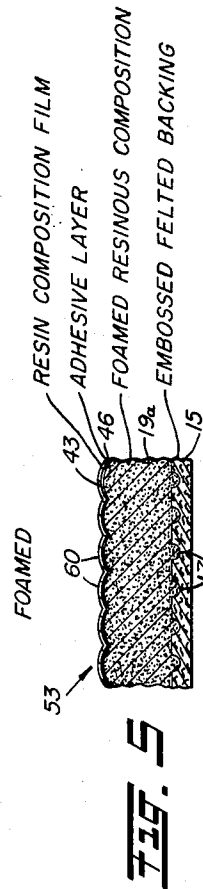


FIG. 5

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3,257,252

METHOD OF MAKING A DECORATIVE SURFACE COVERING

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This invention relates to flexible plastic surface coverings which have a decorative surface and particularly to such products having a foam underlayment.

Printed felt base has a hard, smooth decorative wearing surface. Although this renders the product easily cleaned, the hard surface tends to result in excessive noise from foot traffic. In addition, the hard surface can cause fatigue to those who must stand for long periods of time upon such products. The comfort and quietness of conventional printed felt base is somewhat better than floors of wood and stone due to the cushioning characteristics of the felt backing, but since the felt layer is very thin and on the back of the product, the improvement is only slight. Also, the thin product lacks any appreciable resistance to the flow of heat with the result that printed felt base covered floors tend to be cold, an effect augmented by the smooth and glossy wearing surface.

Efforts have been directed toward improving the resilience of smooth surface floor coverings of which printed felt base is an example. Products with improved resilience can be made by the application of a thin layer of foam rubber to the back of the surface covering. Although this does improve the properties of products such as printed felt base, there are certain disadvantages. Foam rubber is subject to deterioration and chemical attack, particularly if it is installed upon a concrete floor. The resulting breakdown of the cell structure causes the product to lose its resilience. Also, where products are to be adhesively bonded to a surface during installation, the adhesive can become at least partially absorbed into the foam cell structure with resultant loss of at least some of the effect of resilience.

A major source of competition for smooth surface floor coverings, such as printed felt base, is from woven or tufted soft surface carpeting. Carpeting is not only soft and comfortable under foot but also has a three-dimensional textured appearance which is particularly attractive in certain areas in the home. Soft surface carpeting, although highly attractive, has a serious disadvantage in that it readily soils and once soiled it is difficult to clean.

In United States Patent 2,943,949 which issued on July 5, 1960 to Robert K. Petry, entitled "Decorative Plastic Surface Covering and Process Therefor," there is disclosed a product having the desired textured surface and resiliency of soft surface covering such as tufted carpets while still retaining the unitary readily cleanable surface of printed felt base. This product is produced by printing a multicolored design upon a textured backing, such as an embossed flooring felt, with a foamable thermoplastic resinous composition and thereafter heating the printed felt to fuse the resin and foam the thermoplastic composition. The result of this procedure is a resilient product attributable to the foam and having a three-dimensional appearance caused by the embossing. The product therefor simulates carpet while having the ease of cleaning attributes of printed felt base. It has been suggested to increase the soil resistance of the product by applying a thin liquid resinous coating and thereafter drying the coating.

An object of the invention is to produce a decorative

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surface covering characterized by excellent resilience and comfort underfoot while having relatively higher wear resistance. Another object of the invention is to provide a process for producing such a product in a simple and economical manner. A further object of the invention is to produce a resilient surface covering with a textured surface of substantial thickness and which is relatively low in cost. Other objects and the advantages of the invention will appear hereinafter.

In accordance with the invention a resilient surface covering having a textured three-dimensional surface and a flexible backing is produced by coating a textured flexible backing with a foamable thermoplastic resinous composition, gelling the coating, laminating a film to the surface of the gelled coating and thereafter heating the composite product to fuse the resins and foam the coating. The product is a three-dimensional foamed structure having a textured surface of substantial thickness, an interlayer of foam and a flexible backing.

The invention will be better understood from the following detailed description when read in conjunction with the drawings wherein

FIGURE 1 is a schematic representation of a method of producing a surface covering in accordance with the present invention;

FIGURE 2 is an enlarged cross sectional view of a textured flexible backing for use in preparing products of the invention taken along line 2'-2' in FIG. 1;

FIGURE 3 is an enlarged cross sectional view of the backing of FIGURE 2 with a coating composition applied thereto taken along line 3'-3' in FIG. 1;

FIGURE 4 is an enlarged cross sectional view of the coated backing of FIGURE 3 having a printed design on its surface taken along line 4'-4' in FIG. 1; and

FIGURE 5 is an enlarged cross sectional view of a three-dimensional surface covering produced by the method of FIGURE 1 taken along line 5'-5' in FIG. 1.

With reference to FIGURE 1, a sheet of impregnated felted fibrous backing material 11 passes through an embossing unit comprising an upper embossed roll 12 and a lower pressure roll 13. The embossed roll 12 has a plurality of spaced protuberances 14 which are provided in the pattern to be embossed in the backing sheet. The embossed felted backing 15 then passes beneath a doctor blade 18 which allows a uniform layer of resinous composition 19 containing a foaming agent to be applied to the surface of the web from a reservoir 20 maintained in front of the doctor blade 18. The coating is sufficient to fill the depressions 17 and form a flat uniform surface. The coated felt passes to an endless belt 22 provided with pins 25 which project vertically from the belt at spaced points on its edges throughout its entire length. The belt 22 passes around and is driven by wheels 23, 24. The web of embossed felt 15 is engaged by the pins 25 which pierce the side edges of the web and advance it along. The coated felt is carried by the endless belt 22 to a heating oven 30 such as one provided with infra-red heat lamps 31. The oven supplies sufficient heat to the resinous composition to partially or completely solvate the resin in the composition without decomposing the foaming agent contained in the composition. The heated felt is then passed between steel laminating rolls 41 and 42. A film 43 of compatible resinous composition is fed from supply roll 44 to the laminating rolls 41 and 42 which laminate the film to the surface of the gelled resinous composition. Preferably an adhesive 46 can be applied to the surface of the film and/or gelled layer to aid in adhesion of the two components. The use of laminating

rolls 41 and 42 is desirable to remove any air between the two surfaces to be combined although they can be dispensed with and the film 43 can be laid on top of the gelled layer. The adhesive can be applied in any of the conventional ways such as by means of a doctor blade 45. The composite sheet 47 passes through an oven 51 such as infrared heat lamps 52 in which the resin composition 19 is fused by complete gellation, if not previously accomplished and foamed. The product is withdrawn from the oven and passed through a cooling chamber 55. The product 53 has a foam interlayer 19a bearing a plurality of raised portions 60 which correspond in location to the depressed portions 17 in the embossed felt backing. The surface film 43 overlays the foam interlayer 19a and has the textured appearance of the embossed felt. The product can be used in sheet form as produced or can be cut up into tiles or other appropriate shapes.

The procedure described above relates to a solid color product wherein the color is either supplied by pigmenting the foam layer and/or the film. If a decorated product is desired, a design can be printed either on the gelled foamable layer or the underside of the film. Such printing is conventional and can be carried out using printing inks which are compatible with the resinous composition. As an illustration, if the film is a vinyl composition film, inks having a vinyl resin base can be utilized and applied by the well known rotogravure printing procedure. Since the printing is under a protective layer, the backing sheet is preferably a flexible strong material which will remain part of the product. Backing materials can be used, however, which are subsequently stripped from the final product, such as, strippable coated paper or the like. If backing remains, flexibility is important since the product is conventionally stored in closely wound rolls and must be capable of being rolled and unrolled without cracking or tearing. Strength is important in a backing in view of the strains to which the product is subjected when handled both during manufacture and immediately prior to installation.

The backing sheet must bear a texture in the form of depressed and raised portions in accordance with the particular three-dimensional overall effect desired in the finished product. The contrast between the depressed and raised portions should be at least 5 mils; that is, the depressed portions should lie at least 5 mils below the raised portions in the textured backing sheet. Where a backing naturally bearing a smooth surface is used, this backing sheet can be embossed to produce the desired texture. Any of the conventional techniques of embossing such as flat bed or rotary embossing can be used. Where a backing sheet in its natural state already possesses the desired type and character of texture, no embossing is necessary. Coarse woven fabrics possess natural texture and when they are used as backings, the outline and effect of the weave is formed in the foam structure in the finished product. Where other types of three-dimensional effects are desired in the finished product, it is preferably to use a natural smooth backing sheet which is embossed in the desired pattern. The embossing can be in any desired pattern, but the best appearance is created by a uniform overall embossing, for example, a series of evenly spaced depressions as illustrated in FIGURE 2 or more elaborate embossing, if such an effect is desired. The shape and position of the depressed areas in the backing will conform to the raised areas in the finished product. The deeper the embossing or texture in the backing, the greater will be the three-dimensional effect in the product.

Suitable backing sheets include those formed of flexible resinous composition as well as sheets of woven fabric and impregnated felted fibers. Any of the thermoplastic or elastomer resinous compositions which can be calendered or pressed to form a flexible sheet can be used to form backing sheets which can be textured for use in the invention. Such resins as butadiene-styrene copolymer, polymerized chloroprene, polyvinyl chloride, polyvinyl acetate, vinyl chloride-vinyl acetate copolymer and the

like can be compounded with plasticizers and fillers and sheeted to form a flexible sheet. In some cases, scrap and degraded resinous compositions can be salvaged by forming them into sheets which can be embossed and used as backing sheets in producing products in accordance with the invention.

Suitable backing sheets also include rough woven fabrics formed of such fibers as cotton, wool and various synthetic fibers. For use in the invention the weave must be sufficiently rough that the depressed portions of the weave lie at least 5 mils beneath the raised portions. Where loosely woven fabrics are used, the fabric can be sized to prevent passage of the coating composition through the openings between the fibers.

It has been found that felted cellulose or asbestos fibrous sheets impregnated with a waterproofing and strengthening saturant can be embossed or otherwise roughly textured to yield desirable backing sheets for the production of products in accordance with the invention since they are low in cost and yet are flexible and strong. The sources of cellulose can include cotton or other rags, wood pulp, paper boxes or mixtures thereof in any proportion. In addition, fillers such as wood flour can be used. A slurry of fibrous material in water is formed into a sheet using any of the techniques conventionally employed in the manufacture of paper. For example, sheet formulation can take place on a Fourdrinier or cylinder sheet forming machine. The fibrous sheet so prepared is then dried. In addition to cellulose and asbestos, other fibers can be used including synthetic fibers and those of mineral and animal origin.

Felted fibrous sheets as produced by conventional sheet forming techniques are usually unsatisfactory for use as backings for surface covering products without impregnation due to poor strength and water resistance. Impregnation with a water-proofing and strengthening impregnant is therefore required.

The particular impregnant chosen must not only be capable of imparting strength and water resistance to the sheet of felted fibers but must also meet other requirements as to its physical and chemical behavior at high temperatures. The foamable composition applied to the backing in accordance with the invention must be heated to temperatures as high as 300 to 400° F. in order to fuse the resin and expand the composition into a foam. Thus, the impregnant chosen must be stable at these temperatures. The impregnant should be substantially free of any components which are volatile at these temperatures and it also must not soften to such an extent as to exude from the sheet. In addition, the saturant should not be subject to appreciable detrimental changes such as oxidation.

The conventional impregnant used in the manufacture of printed felt base coverings of the prior art has been asphalt. Although asphalt is very low in cost, it is a highly thermoplastic substance and in general is too fluid at high temperatures for use as an impregnant for felt in the production of products in accordance with the invention. Asphalt saturated felt can only be used as a backing sheet in the invention where the level of impregnation is controlled not to exceed 115 percent by weight based on the weight of dry felt and where the surface on which the decorative composition is printed bears a plurality of sealing coats of paint comprising such binders as butadiene-styrene copolymer, vinylidene chloride copolymer and the like. There are other saturants which can be used in place of asphalt to impart strength and water resistance to felt and which can withstand temperatures up to 400° F. for short periods of time, i.e. two to five minutes, without the necessity of providing special sealing coats. Fibrous sheets impregnated with resinous materials are particularly suitable for use as backing sheets in the invention. Suitable resins include vinyl resins, such as copolymers of vinyl chloride, polymerized acrylic and methacrylic acids and their polymerized derivatives

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polyethylene polystyrene, butadiene-styrene copolymer, butadiene-acrylonitrile copolymer, natural rubber, polymerized chloroprene and the like. Thermosetting resins which under the influence of heat cure by polymerizing and cross-linking can also be used as impregnants. Such resins as phenolic resins, polyesters, oleoresins such as drying oil and the like, isocyanates and polyurethanes and the like are suitable.

Such resins can be incorporated into a felted fibrous sheet by impregnation of the finished sheet with an emulsion or solution of the resin followed by drying of the sheet to remove the solvent. Alternately, the resin can be added in fine particles to the fiber furnish prior to sheet formation either as solid particles or resin or as an emulsion in water or other emulsifying vehicle.

Some resin impregnants which produce a felted sheet with excellent physical properties are not compatible with the foamable composition to be applied. This may result in poor adhesion of the foam to the base and in loss of fidelity of the embossed felt design in the foam surface. In such cases, it is desirable to size the surface of the impregnated felt sheet which the foamable composition is to be applied with a thin coating of material which has good adhesion to both the felt impregnant and the foamable composition. Where a plasticized polyvinyl chloride polymer foam is used, excellent results have been obtained over a wide variety of felt impregnants using a size of acrylic polymer latex. A mixture of equal parts of Rhoplex B-15, a soft acrylic polymer latex and Rhoplex B-85, a hard acrylic polymer latex, both made by Rohm and Haas Co., Philadelphia, Pennsylvania, has been found particularly effective in aiding adhesion fidelity of the textured design, without causing sticking of the sized surface to the embossing roll during the embossing process. The coating is effective in small amounts, an application of only 0.02 pound dry weight per square yard being sufficient to obtain the improvements. Other materials can be similarly used, depending upon the type of felt impregnant and foam applied thereon. A butadiene-acrylonitrile polymer latex either alone or in combination with hard resin emulsions such as Vinsol, a wood rosin derivative made by Hercules Powder Company, Wilmington, Delaware, is effective.

In accordance with the invention, a coating is applied to the textured backing with a fluid foamable composition. Suitable coating compositions comprise a thermoplastic resinous binder and a substance which is decomposed by heat to yield a foam producing gas, all dispersed in a liquid medium. The self supporting film thereafter applied can have the same composition as the coating with the omission of the foaming agent.

The resinous binder in the foamable coating must be one that is coalesced or fused into a continuous film by the application of heat. The vinyl resins are preferred since they are readily adaptable to use as plastisols, but other thermoplastic resins can be used such as polymers and copolymers of acrylic acid and methacrylic acid and their derivatives, polystyrene, polymerized methyl styrene, polybutadiene and the like. It should be understood however, that some of these latter resins are only available in latex form and, therefore, it would be necessary to remove the water after applying the coating prior to further treatment. A plastisol can be defined as a thermoplastic resin in the form of fine particles thoroughly and uniformly dispersed in plasticizer in the presence of small amounts of pigments and stabilizers. A plastisol has appreciable fluidity at normal room temperatures but is converted by heat into a flexible, tough thermoplastic mass. This ultimate result is brought about by the process of fusion wherein the resin becomes plasticized and solvated by the plasticizer.

Polymers of vinyl chloride have been found to be particularly effective in formulating plastisol coating and printing compositions for use in the invention. The vinyl

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chloride polymers can either be simple, unmixed homopolymers of vinyl chloride or copolymers thereof in which the essential polymeric structure of polyvinyl chloride is interspersed at intervals with the residues of other ethylenically unsaturated compounds copolymerized therewith. The essential properties of the polymeric structure of polyvinyl chloride will be retained if not more than 40 percent of the extraneous comonomer is copolymerized therein. Suitable extraneous comonomers include, for instance, vinyl esters on the order of vinyl bromide, vinyl fluoride, vinyl acetate, vinyl chloroacetate, vinyl butyrate, other fatty acid vinyl esters, vinyl alkyl sulfonates, trichloroethylene and the like; vinyl ethers such as vinyl ethyl ether, vinyl isopropyl ether, vinyl chloroethyl ether and the like; cyclic unsaturated compounds such as styrene, the mono- and polychlorostyrenes, coumarone, indene, vinyl naphthalenes, vinyl pyridines, vinyl pyrrole and the like; acrylic acid and its derivatives such as ethyl acrylate, methyl methacrylate, ethyl methacrylate, ethyl chloroacrylate, acrylonitrile, methacrylonitrile, diethyl maleate, diethyl fumarate and the like; vinylidene bromide, vinylidene fluorochloride and the like; unsaturated hydrocarbons such as ethylene, propylene, isobutene and the like; allyl compounds such as allyl acetate, allyl chloride, allyl ethyl ether and the like; and conjugated and cross-conjugated ethylenically unsaturated compounds such as butadiene; isoprene; chloroprene; 2,3-dimethyl-butadiene-1,3; piperylene; divinyl ketone and the like.

Resins adaptable for use in formulating vinyl chloride plastisols are commonly referred to as dispersion grade resins. Such resins are available having particle sizes of from about 0.02 to about 2 microns in contrast to calendar grade vinyl chloride resins which are available in particles ranging up to 35 microns in size. Dispersion grade resins are usually of higher molecular weight than calendar grade resins and have particle surfaces of a hard, horny nature.

Polymers of vinyl chloride having specific viscosities above about 0.17 and preferably between 0.17 and about 0.31 as measured in a solution of 0.2 gram of resin in 100 milliliters of nitrobenzene at 20° C. are particularly effective.

In the determination of specific viscosities a sample of resin in nitrobenzene solution maintained at a temperature of 20° C. is allowed to flow between two calibrated marks in a pipette and the time required for the flow is recorded. This time is compared with the time required for a control of pure nitrobenzene solvent to pass between the same two marks, also at a temperature of 20° C. The specific viscosity is determined as the sample flow time divided by the control flow time, minus 1. The specific viscosity is an effective measure of relative molecular weight of the polymer, the higher the specific viscosity the higher being the molecular weight.

In the formulation of plastisols for use in the invention, the fine particle size resin is uniformly dispersed in a mass of fluid plasticizer. The fluidity of plastisols is influenced in part by the particular resin selected but is also a function of the ratio of plasticizer to resin. Plastisols become less fluid as the ratio of plasticizer to resin is reduced. Plastisol coating compositions for use in the invention contain from about 40 to about 150 parts plasticizer per 100 parts resin with a range of 50 to 100 parts plasticizer per 100 parts resin being particularly effective. The viscosity of plastisol coating compositions can also be reduced by the addition of small amounts of a volatile diluent not exceeding about 10 parts per 100 parts resin. Useful diluents include benzene, toluene, petroleum solvents such as V.M. and P. Naphtha (Boiling Range—190–275° F.) and the like. Particularly suitable coating compositions have a viscosity at 25° C. of from about 200 to about 25,000 centipoises as measured with a Brookfield viscometer using a Number 6 spindle at 10 r.p.m.

The self supporting film preferably has a composition which is similar to that of the coating composition because this simplifies compatibility of the two layers. The film can, however, have any of the compositions given above for the coating. The film is formed by any of the conventional methods used by film manufacturers such as calendering, casting or extrusion.

The adhesive which is preferably utilized to aid adhesion between the gelled foam and the film can be any of the conventional adhesives utilized for binding resinous compositions together. It must, however, be stabilized at the high temperatures required to decompose the foaming agent. A particularly suitable adhesive is a thin layer of plastisol of composition similar to the foamable coating with the omission of the foaming agent. Plastisol type of adhesives are preferred since they do not require the removal of a solvent carrier.

It is essential to the invention that the foaming coating and the film have substantially the same degree of softness at elevated temperatures. This result can be accomplished by balancing the plasticizer efficiency in both compositions. That is, the amount and kind of plasticizer utilized in the composition should result in the respective compositions having the same degree of plasticity at high temperatures. This is essential since if the film is substantially softer than the foamable coating, the gas given off by the foaming agent will go into the film layer thereby reducing its solid thickness if not eliminating it altogether. In addition, if the film is too hard it will so depress the gas given off as to hinder the reproduction of the embossed areas of the flexible backing in the film layer. The plasticity at elevated temperatures can also be influenced by the molecular weight of the resin used, less plasticizer being required with the lower molecular weight resins. As a general rule, the two compositions should fuse at approximately the same temperature which would indicate that the compositions have substantially the same degree of softness. It has been discovered that the thickness of the film is critical. If the thickness is less than two mils the gas from the lower coating will pass right through it thereby completely losing the desired solid surface layer. In addition, the thicker the coating over eight mils the more depressed is the fidelity in producing the embossed design.

The selection of the plasticizer is important in determining the strength and flexibility of the product and also in influencing the foaming characteristics of the coating. Esters of straight and branched chain alcohols with aliphatic acids impart low viscosity and good viscosity stability to a plastisol. Typical plasticizers of this type include dibutyl sebacate, dioctyl azelate, triethylene glycol di (2-ethylhexanoate), diethylene glycol dipelargonate, triethylene glycol dicaprylate and the like. Plasticizers of the aromatic type, such as esters of aliphatic alcohols and aromatic acids or aromatic alcohols and aliphatic acids or aromatic alcohols and aromatic acids are desirable in that they impart good foaming characteristics to a plastisol, although the use of highly aromatic plasticizers is limited by their tendency to yield plastisols of high viscosity. Typical plasticizers of this type include dibutyl phthalate, dicapryl phthalate, dioctyl phthalate, dibutoxy ethyl phthalate, dipropylene glycol dibenzoate, butyl benzyl sebacate, butyl benzyl phthalate, dibenzyl sebacate, dibenzyl phthalate and the like. Other types of plasticizers, such as esters of inorganic acids, including tricresyl phosphate, octyl diphenyl phosphate and the like, alkyl derivatives of rosin, chlorinated paraffine, high molecular weight hydrocarbon condensates and the like can also be used. The plasticizer or blend of plasticizers is chosen to yield a plastisol of the desired viscosity and foaming characteristics. In addition, the plasticizer should have a low vapor pressure at the temperatures required to fuse the resin. A

vapor pressure of 2 millimeters of mercury or less at 400° F. is satisfactory.

Minor amounts of stabilizers which are incorporated to reduce the effects of degradation by light and heat are present in the composition. Suitable light stabilizers include resorcinol disalicylate, resorcinol dibenzoate, phenyl phthalate, phenyl benzoate, o-tolyl benzoate, eugenol, guaiacol, o-nitrophenol, o-nitraniline, triethylene glycol salicylate, and organic phosphates and other complexes of such metals as barium, cadmium, strontium, lead, tin and the like. Suitable heat stabilizers include sulfides and sulfites of aluminum, silver, calcium, cadmium, magnesium, cerium, sodium strontium and the like, glycerine, leucine, alanine, o- and p-amino benzoic and sulfanilic acids, hexamethylene tetramine, weak acid radicals including oleates, ricinoleates, abietates, salicylates and the like. Normally, the compositions contain from 0.5 to 5 parts stabilizer per 100 parts resin.

The foamable plastisol composition contains in addition, an effective amount of a foaming agent. The larger the amount of foaming agent within practical limits used the greater is the expansion of the foam. Foam densities of from 10 percent to 50 percent of the density of the unblown plastisol can be readily attained. Such results are attainable with from about 1 to about 20 parts foaming agent per 100 parts resin with from 2 to 10 parts foaming agent per 100 parts resin being particularly effective for the production of foams of a density which are most desirable for use in producing surface coverings in accordance with the invention.

Complex organic compounds which when heated decompose to yield an inert gas have residues which are compatible with the resin used in the plastisol are preferred as foaming agents. Such materials have the property of decomposition over a narrow temperature range which is particularly desirable for obtaining a good foam structure. Compounds having the $>N-N<$ and $-N=N-$ linkages decompose at elevated temperatures to yield an inert gas high in nitrogen. Typical compounds of this type include substituted nitroso compounds, substituted hydrazides, substituted azo compounds and the like, such as are tabulated below:

Foaming agent:	Decomposition temperature, ° F.
P,P'-oxybis-(benzenesulfonyl hydrazide) --	300-320
N,N' - dimethyl - N,N'-dinitroso terephthal-	
amide -----	200-220
Dinitrosopentamethylenetetramine -----	355-375
Azodiformamide -----	370-390

Foaming agents for use in the invention must be decomposed an effective amount at a temperature below the decomposition temperature of the resin used. Therefore, in the case of plastisols formulated with the preferred vinyl chloride polymers, a foaming agent decomposing below 450° F. must be used. The minimum initial decomposition temperature must be sufficiently high that no premature gas evolution occurs during plastisol formulation and subsequent gelling of the coating. In addition, the minimum decomposition temperature of the foaming agent must be at a temperature where the coating can be gelled by heat without evolving gas. In general, vinyl chloride polymer plastisols attain body through partial gelation when heated to about 200° F. Thus the minimum initial decomposition temperature should be about 200° F. or higher.

The use of foaming agents which decompose at the fusion temperature of the polymer is particularly effective. A layer of resinous foam has heat insulating properties with the result that fusion of a prefoamed layer can be difficult. Thus, particularly effective foaming agents are those which decompose over a temperature range from the polymer fusion temperature or higher up to the decomposition temperature of the polymer. Azodiformamide is a particularly effective foaming agent of this type.

The degree of foaming of a typical plastisol formula-

tion using different concentrations of foaming agent is shown in the following table:

Parts Azodiformamide per 100 parts resin	Blow Ratio (Foam thickness/original thickness)	Foam Density (lbs. per cu. ft.)
0.0	1/1	80
0.1	1.33/1	60
0.5	2/1	40
1.0	3/1	27
2.0	4.5/1	17.5
3.0	6.5/1	12.3
5.0	9.3/1	8.6
10.0	10.7/1	7.5

After application of the foamable layer the composition is heated to a temperature sufficient to gel the composition in order to facilitate the lamination of the self-supporting film. The heating should be low enough, however, to prevent decomposing of the foaming agent. The gelling takes place by partial or complete solvation of the resin. The amount of heat applied will depend on the resin and plasticizer components but with most vinyl resins, a temperature of between 150° F. and 300° F. for a period of two to thirty seconds is sufficient. If desired, partial or complete fusion of the resin can take place. After lamination of the film, the composition is heated to a temperature sufficient to fuse the resin and decompose the foaming agent. The temperature of the entire mass of composition upon the backing must attain the fusion temperature to produce a product of satisfactory strength. In addition, the entire mass of foamable composition must be heated to a point where the foaming agent is decomposed. Where a preferred high temperature foaming agent is used, foaming does not occur until the resinous composition has been completely fused. It is essential for the self-supporting film to be firmly bonded to the coating before foaming takes place.

If volatile diluents are used to reduce the viscosity of the coating composition, care must be taken that they are essentially completely removed from the coating prior to the application of the film, otherwise poor cell structure and blister formation will result. Such removal can be accomplished by heating the composition at a temperature substantially below the fusion temperature and minimum decomposition temperature of the foaming agent for sufficient time to remove the volatile material. For example, if 5 per cent of V.M. & P. Naphtha (Boiling Range 190–275° F.) is used, heating at 300° F. for three minutes will remove sufficient material so that fusion and foaming at 400° F. can be accomplished with good cell structure and freedom from blisters.

Heating in order to effect fusion and foaming can be brought about with infrared heat lamps as shown in the drawing or other types of heating such as forced hot air oven or dielectric heating can be used. In some instances, it is desirable to heat the web from both sides to offset the insulating effect of the foam.

The expansion of the coating due to foaming yields a three-dimensional textured effect which duplicates in reverse the texture in the backing. That is, depressions in the backing appear as raised areas of foam. The size of the raised areas in the foamed product depends on the depth of the depressed areas in the backing and the amount of expansion in the foaming process. The film is unimpaired by the foaming, in that the foamed surface accurately reproduces the textured pattern in the film. If a decoration is printed on the underside of the film the decorative effect is enhanced by the three-dimensional texture present in the surface of the product.

There are certain limitations in reproducing the embossed felt design in the foam surface. Very fine and delicate embossings where the depth and width are less than about .005 inch are difficult to reproduce with good fidelity by this process. Similarly, embossings deeper than about .050 inch produce large texture effects in

the foam surface and lose detail. Embossings which have an average depth and width of from about .015 inch to about .030 inch have given best results.

If the expansion of the foamable composition applied to the embossed felt is too low, there will not be enough contrast between the high and low areas to produce a good textured effect. On the other hand, too great an expansion will result in a coarser foam structure which impairs design fidelity. For embossed felt depths of .015 inch to .030 inch a foam expansion of about 300% to about 800% can give good design fidelity. With the preferred composition, a plasticized polyvinyl chloride foam, expansions of about 500% to about 600% give the best combination of good design fidelity and foam structure.

The texture is also affected by the total thickness of the foam layer. In general, the foam thickness should be from 3 to 10 times the average depth of felt embossing, but this is largely dependent upon the design selected. For the preferred embossing depths of from about 0.015 inch to about 0.030 inch, the foam thickness should not exceed about 0.250 inch and about 0.100 inch to about 0.150 inch is preferred.

In order that the texture of the backing be accurately reproduced in the foamed product, it is important that the coating flow into the fill all the depressions in the textured backing and become completely level so as to have a smooth surface prior to lamination and foaming.

The foamed and fused product after leaving the heating oven is permitted to cool. Cooling is particularly important since any premature handling of the product immediately after foaming might cause partial collapse and distortion of the foam structure. Cooling can be brought about by mere exposure of the product to the atmosphere; thus, the speed of motion of the backing along the processing apparatus can be adjusted so that the product is given sufficient time to cool. Alternately, cooling can be accelerated by blowing jets of cooled air upon the fused and foamed composition or by means of fine sprays of water upon the fused and foamed composition.

After being cooled, the product is withdrawn from the processing apparatus. It can be used in the form of a sheet as produced or can be cut into tiles or other appropriate shapes depending on the particular use to which the product is to be put. Products produced in accordance with the invention have the characteristics of excellent soil resistance and resiliency under foot in view of the foamed layer. They are also characterized by having a marked three-dimensional textured appearance conforming to the texture of the backing. Still further, the products of the invention have good heat insulating properties by virtue of the layer of foamed composition and thus are warmer in winter and cooler in summer than conventional smooth surface coverings of the prior art.

The following examples are given for purposes of illustration:

Example I

A foamable plastisol was formulated by grinding the following ingredients on a conventional three-roll mill:

	Parts
Vinyl chloride-vinyl acetate copolymer (dispersion grade)	100
Diocetyl phthalate	30
Dipropylene glycol dibenzoate	30
Stabilizer	6
Finely divided titanium dioxide	2.5
Azodiformamide foaming agent	2.5

The plastisol had a viscosity of 16,800 centipoises at 25° C. as measured with a Brookfield viscometer using a No. 6 spindle at 10 r.p.m. This plastisol can be pig-

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mented as desired to produce compositions for use in accordance with the invention.

Example II

The following ingredients in the proportions indicated were ground on a three-roll mill to produce a foamable coating composition:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Petroleum hydrocarbon condensate ¹ -----	18
Butyl benzyl phthalate -----	52
Pigment -----	2
Stabilizers -----	4
Azodiformamide foaming agent -----	3.5

¹ Conoco H300—Continental Oil Company, Ponca City, Okla.

The plastisol had a viscosity of 4,000 centipoises as measured with a Brookfield viscometer using a No. 6 spindle at 10 r.p.m.

Example III

The following ingredients were ground on a three-roll mill to produce a foamable coating composition:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Petroleum hydrocarbon condensate ¹ -----	18
Butyl benzyl phthalate -----	52
Pigment -----	3
Stabilizers -----	4
Azodiformamide foaming agent -----	3.5
V.M. and P. Naphtha Boiling Range 190 to 275° F. -	5

¹ Conoco H300—Continental Oil Company, Ponca City, Okla.

The plastisol had a viscosity of 2,000 centipoises as measured with a Brookfield viscometer using a No. 6 spindle at 10 r.p.m.

Example IV

The following ingredients in the proportions indicated were ground on a three-roll mill to produce a foamable coating composition:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Didecyl phthalate -----	100
Stabilizers -----	5
Pigment -----	2
Wetting agent -----	3.5
N,N'-dimethyl-N,N'-dinitroso terephthalamide foaming agent -----	5

The plastisol had a viscosity of 2,000 centipoises as measured with a Brookfield viscometer using a No. 6 spindle at 10 r.p.m.

Example V

The following ingredients in the proportions indicated were ground on a three-roll mill to produce a foamable coating composition:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Didecyl phthalate -----	60
Didecyl adipate -----	25
Stabilizer -----	5
Pigment -----	2
Wetting agent -----	3.5
N,N'-dimethyl-N,N'-dinitroso terephthalamide foaming agent -----	5

The plastisol had a viscosity of 1,350 centipoises as measured with a Brookfield viscometer using a No. 6 spindle at 10 r.p.m.

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Example VI

The following ingredients in the proportions indicated were ground on a three-roll mill to produce a foamable coating composition:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Petroleum hydrocarbon condensate ¹ -----	18
Butyl benzyl phthalate -----	52
Pigment -----	3
Stabilizers -----	4
Azodiformamide foaming agent -----	4.5

¹ Conoco H300—Continental Oil Company, Ponca City, Okla.

The plastisol had a viscosity of 4,000 centipoises as measured with a Brookfield viscometer using a No. 6 spindle at 10 r.p.m.

Example VII

A clear film of four mils thickness was prepared by passing the following composition through calender rolls after mixing:

	Parts
Polyvinyl chloride (calender grade) -----	100
Diocetyl phthalate -----	50
Stabilizer -----	2
Lubricant -----	0.5

Example VIII

The following ingredients in the proportions indicated were ground on a three-roll mill to form a plastisol for use as an adhesive for a vinyl film:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Petroleum Hydrocarbon Condensate ¹ -----	25
Butyl benzyl phthalate -----	75
Stabilizers -----	4

¹ Conoco H300—Continental Oil Company, Ponca City, Okla.

Example IX

A sheet of felted cellulose fibers (.045 inch thick) was produced containing 25 percent by weight of the fibers, of polyvinyl acetate dispersed in fine particulate form at junctions of fibers within the sheet. The sheet was embossed to a depth of 0.020 inch in a plurality of evenly spaced depressions about 0.010 inch in width. The foamable plastisol composition of Example II was coated on the surface of the sheet by means of a doctor blade to form a coating having a thickness of 0.010 inch. The depth of coating over one of the embossed areas was therefore 0.030 inch thick. The coating was then subjected to heat at 200° F. for a period of forty-five seconds to gel the coating without decomposing the foaming agent. A thin layer of plastisol was applied to the surface of the gelled layer. A flexible vinyl self-supporting film having a thickness of 4 mils with a design printed on one surface was placed on the surface of the plastisol coated layer and passed between laminating rolls. The printed decoration on the film is in contact with the plastisol. The composite sheet was then passed through an oven maintained at 400° F. with a residence time of three minutes, thereby fusing the composition and expanding and foaming the product. The foamable composition expanded to yield a product having a minimum foam thickness of about 60 mils with a plurality of raised areas conforming in location to the embossed depressions in the backing. The surface of the product had a solid vinyl composition of about 4 mils thickness free of any gas or foam areas.

Example X

A sheet of felted cellulose fibers having a thickness of 0.045 inch containing 25 percent by weight of the fibers of polyvinyl acetate dispersed in fine particulate form at junction of fibers within the sheet. The sheets was em-

bossed to a depth of 0.030 inch to provide a plurality of evenly spaced depressions in the surface of the felt of average width of about 0.020 inch. The foamable plastisol composition of Example VI was prepared and pigmented in a blue color. The plastisol of Example VI was coated by means of a doctor blade over the surface of the felt bearing the depressions in such a way that the composition completely filled the depressions and gave a smooth coating of 0.010 inch thick at its maximum thickness. A clear polyvinyl chloride film of 5 mils thickness was placed on the surface of the coating. The composite product was then heated to a temperature of 200° F. for ninety seconds to gel the coating and bind the film to the coating. The sheet was then passed through an oven at 400° F. for three minutes, thereby fusing the polyvinyl chloride in the plastisols and decomposing the foaming agent to foam the plastisol compositions. The product bore a layer of foam over the raised unembossed areas of the felt having an average thickness of about 70 mils with a plurality of raised areas conforming to the embossed depressions in the backing. The entire surface of the product has a solid film layer of about 0.005 inch in thickness.

Any departure from the foregoing description which conforms to the present invention is intended to be included within the scope of the claims.

What is claimed is:

1. In a method of producing a decorative surface covering having a cellular layer which comprises completely covering one surface of a flexible sheet having on such surface a plurality of areas depressed below said surface with a smooth layer of resinous composition containing a foaming agent, heating said layer to fuse said composition and decompose said foaming agent to expand said resinous composition layer to form said cellular layer surface covering having a plurality of raised portions overlaying and conforming in character and spacing to said depressed areas in said one surface and thereafter cooling the expanded layer, the improvement which comprises heating said smooth layer of resinous composition to gel said composition without decomposing said foaming agent, laminating a film of resinous composition of at least 0.002 inch in thickness to the upper surface of said gelled layer and then heating the composite sheet

to decompose the foaming agent contained in said gelled layer.

2. The method according to claim 1 wherein said resinous composition containing a foaming agent is a plastisol of a vinyl chloride polymer comprising about 50 to about 150 parts of plasticizer per 100 parts vinyl chloride polymer.

3. The method according to claim 1 wherein a size coat of an acrylic polymer is applied to the surface of the flexible sheet prior to covering the flexible sheet with said smooth layer.

4. The method according to claim 1 wherein said film has a maximum thickness of 8 mils.

5. The method according to claim 1 wherein said flexible sheet is stripped from the composite expanded layer and film after said cooling.

6. The method according to claim 1 wherein said film is transparent and a decorative design is applied between said film and said gelled layer.

7. The method according to claim 1 wherein said cellular layer and said film comprise vinyl polymer compositions.

8. The method according to claim 7 wherein said vinyl polymer compositions fuse at approximately the same temperature.

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