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DECORATIVE PLASTIC SURFACE COVERING AND PROCESS THEREFOR

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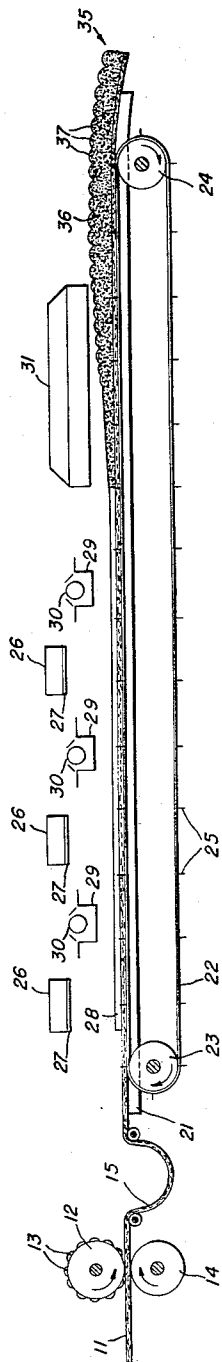


FIG. 1

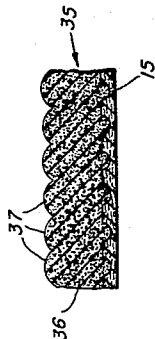


FIG. 4

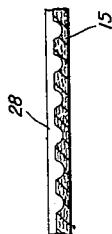


FIG. 3

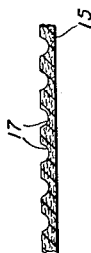


FIG. 2

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DECORATIVE PLASTIC SURFACE COVERING AND PROCESS THEREFOR

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22 Claims. (Cl. 117—11)

This invention relates to flexible decorative surface coverings which have a printed decorative wearing surface applied to a backing and to a method of producing such coverings.

Printed products adaptable as decorative and protective coverings for floors, walls and the like have been available for many years. The technique of printing an oleoresinous enamel paint decoration upon a flexible backing sheet has been used commercially for at least 40 years to produce products commonly referred to as printed felt base. Such products have the desirable feature of being low in cost and they can be readily manufactured in a variety of attractive designs.

Printed felt base has a hard and smooth decorative wearing surface. Although this renders the product easily cleaned, the hard surface tends to result in excessive noise from foot traffic. Also, the hard surface can cause fatigue to those who must stand for long periods of time upon such products. The comfort and noise production 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 in winter, an effect augmented by the smooth and glossy wearing surface.

Resilient floor coverings are available which are quiet and comfortable under foot by utilizing the resilient properties of a material such as rubber. Rubber floor tile with a thickness of $\frac{1}{8}$ inch is relatively quiet and comfortable under foot. However, the product is expensive and also tends to be cool in winter due to its high thermal conductivity.

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. The foam rubber layer is subject to deterioration and chemical attack, particularly if the product 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 adsorbed into the foam cell structure with resultant loss of at least a portion 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. Conventional printed felt base has a hard glossy wearing surface which is desirable in certain areas. There are, however, locations

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and decorating styles where extreme gloss and smoothness is not desirable. Carpeting possesses a marked three-dimensional texture due to its thick, readily deformable pile surface, an effect heretofore unobtainable in printed felt base floor coverings.

It is an object of the invention to produce a printed decorative surface covering characterized by excellent resilience and comfort under foot. Another object of the invention is to provide a printed floor covering which has low thermal conductivity and thus is insensitive to changes in floor temperature. Another object of the invention is to provide a printed floor covering which is quiet under foot. A further object of the invention is to produce a resilient surface covering with a resilient wearing surface of substantial thickness and which is relatively low in cost. A still further object of the invention is to provide a printed decorative surface covering which has a marked three-dimensional textured appearance. Additional objects and the advantages of the invention will appear hereinafter.

In accordance with the invention a surface covering having a textured three-dimensional printed foamed surface and a flexible backing is produced by printing upon a textured and flexible backing a foamable thermoplastic resinous composition in the form of a multicolored design and heating to fuse the resin and form the three-dimensional foamed structure.

The invention will be described with reference to 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; Figure 3 is an enlarged cross sectional view of the backing of Figure 2 with a decorative composition applied thereto; and Figure 4 is an enlarged cross sectional view of a three-dimensional printed surface covering produced by the method of Figure 1.

With reference to Figure 1, a sheet of felted fibrous backing material 11 passes through an embossing unit comprising an upper embossed roll 12 bearing a plurality of spaced protuberances 13 which are provided in the pattern to be embossed in the backing sheet. In the embossing unit the felt sheet is contacted by a back up roll 14. The embossed felt sheet 15 bearing depressed portions 17 produced by contact with the embossing roll passes to a standard block printing machine. The block printing machine shown consists of a bed 21 which extends its entire length and width. At each of the opposite sides of the bed is an endless belt 22 provided with pins 25 which project vertically from the belt at spaced points throughout its length. The belt 22 passes around and is driven by wheels 23, 24. The embossed web of backing material 15 is engaged by the pins 25 which pierce the web and is advanced along the machine. The block printing machine is provided with a plurality of vertically reciprocable print blocks 26 which are provided with printing surfaces 27 cut in the form of the design to be printed. Associated with each print block is a paint pot 29 with a roller 30. When the print blocks are at rest at their maximum height, the paint pot with associated roller moves beneath the block thereby transferring a film of printing composition to the printing surface of the block. Through conventional operation of the block printing machine a film of printing composition 28 is applied to the upper surface of the web of backing material. The sheet passes through a hot air oven 31 in which the composition is fused and foamed, thereby producing a decorative foamed layer 36 bearing a plurality of raised foamed portions 37 which correspond in location to the depressed portions in the embossed felt backing. The product 35 is withdrawn from the printing machine and

can be used in sheet form as produced or can be cut up into tiles or to other appropriate shapes.

The operation of the block printing machine illustrated in Figure 1 is conventional and is similar to the operation of such a machine in the production of the conventional printed felt base surface coverings of the prior art. The motion of the web along the length of the machine is in a stepwise fashion controlled by the intermittent motion of wheels 23, 24. When the web is at rest, the printing blocks are depressed and deposit a film of printing composition upon the web. The blocks are then raised and the web advances a distance equal to the width of each print block. In a conventional block printing machine, the printing blocks are 18 inches in width and are spaced 18 inches apart. The sheet therefore, moves intermittently in 18 inch steps along the length of the machine. As the web advances, the paint pots move beneath the printing blocks depositing a fresh film of printing composition on the printing surfaces thereof. The operation is then repeated. There are as many printing blocks as there are individual colors desired in the finished design. Conventional block printing machines have spaces for up to 24 separate printing blocks so that designs of great complexity and diversity of color can be produced.

Since the operation of a block printing machine producing products in accordance with the invention is well established in the art, the means for intermittently rotating the drums and for vertically reciprocating the printing blocks and horizontally reciprocating the paint pots are not shown in the drawing for the sake of simplicity.

The backing sheet on which the decorative design is printed in accordance with the invention is preferably a flexible strong material. 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 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 preferable to use a natural smooth backing sheet which is embossed in the desired pattern. The embossing can be in any desired pattern, for example, a series of evenly spaced depressions as illustrated in Figure 1 or more elaborate embossing, if such an effect is desired. In accordance with the invention 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 compositions 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 such as burlap are used, the fabric can be sized to prevent passage of the printing composition through the openings between the fibers.

It has been found that felted cellulose fibrous sheets impregnated with a water-proofing and strengthening saturant can be embossed or otherwise roughly textured to yield desirable backing sheets for the production of the 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, 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 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 required.

The particular impregnant chosen must not only be capable of imparting strength and water resistance to a sheet of felted fibers but must also meet other requirements as to its physical and chemical behavior at high temperatures. The printed composition applied to the backing in accordance with the invention must be heated to temperatures as high as 300-400° 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 chemical 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 comprising such binders as butadiene-styrene copolymer, vinylidene chloride copolymers 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 of 350° F. without the necessity of providing special sealing coats. Fibrous sheets impregnated with resinous materials are particularly suitable for use as backing sheets in the

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invention. Suitable resins include vinyl resins, such as polyvinyl chloride, mixtures of these with each other, copolymers with each other and with other monomers copolymerizable therewith, polymerized acrylic and methacrylic acids and their polymerized derivatives 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 oils 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.

In accordance with the invention, a decorative design is applied to the textured backing by printing with a fluid foamable printing composition. Suitable printing 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 resinous binder must be one that is coalesced or fused into a continuous film by the application of heat. The vinyl resins are preferred 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. The dispersion medium can be water in the case of an aqueous latex printing fluid, but is preferably a fluid plasticizer for the thermoplastic resin used. Such a dispersion of resin in a plasticizer is conventionally termed a plastisol.

A plastisol is 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 printing compositions for use in the invention. The vinyl 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 compounds on the order of vinylidene chloride, 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 com-

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pounds such as butadiene, isoprene, chloroprene, 2,3-dimethylbutadiene-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 0.02 to about 2 microns in contrast to calender 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 calender 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 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 the 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 time required 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 plastisol printing compositions 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 printing compositions for use in the invention contain from about 50 to about 150 parts plasticizer per 100 parts resin with a range of 60 to 100 parts plasticizer per 100 parts resin being particularly effective. The viscosity of plastisol printing 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, methyl ethyl ketone, petroleum solvents such as V. M. and P naphtha (boiling range=190-275° F.) and the like.

Suitable printing 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. For printing by the flat bed technique as illustrated in the drawing, a viscosity range of about 500 to about 5,000 centipoises is desirable with a range of 1,000 to 3,500 centipoises being particularly effective.

The selection of the plasticizer is important in determining the strength and flexibility of the wearing surface of the printed surface covering and also in influencing the viscosity and viscosity stability of the printing fluid and its foaming characteristics. 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 sebacate, dioctyl adipate, didecyl adipate, 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, alkyd 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 acid, sulfanilic acids, hexamethylene tetramine, weak acid radicals including oleates, recinoleates, abietates, salicylates and the like. Normally, the printing fluid contains from 0.5 to 5 parts stabilizer per 100 parts resin. The particular stabilizers chosen should not impart excessive viscosity to the printing composition.

The printing composition contains pigments in accordance with the particular color desired. Where a multi-colored decorative effect is created in accordance with the invention, separate batches of printing fluid for each of the colors desired are needed. Any of the organic and inorganic pigments well known in the art for pigmenting resinous compositions can be used. Normally, from 0.5 to 5 parts pigments per 100 parts resin are used.

The foamable plastisol composition contains in addition, an effective amount of a blowing agent. The larger the amount of blowing 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 blowing agent per 100 parts resin with from 2 to 10 parts blowing 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 and have residues which are compatible with the resin used in the plastisol are preferred as blowing 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 include substituted nitroso compounds, substituted hydrazides, substituted azo compounds and the like, such as are tabulated below:

Blowing Agent	Decomposition Temperature, ° F.
P,P'-oxybis-(benzenesulfonyl hydrazide).....	300-320.
N,N'-dimethyl-N,N'-dinitroso terephthalamide.....	200-220
dinitrosopentamethylenetetramine.....	355-375
azodiformamide.....	370-390

Blowing agents for use in the invention must be decomposed an effective amount at a temperature below the decomposition temperature of the resin used. There-

fore, in the case of plastisols formulated with the preferred vinyl chloride polymers, a blowing 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 printing. Such premature gas evolution renders printing difficult. In addition, the minimum decomposition temperature of the blowing agent must be at a temperature where the printed film has sufficient body to retain the bubbles of evolved 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 blowing 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 blowing 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 blowing agent of this type.

When the technique of block pointing is used to produce a decorative design, a film of decorative composition of appreciable thickness is applied to the rough textured backing material. Printed films of 5 to 10 mils in thickness can be applied by block printing. When a film of this thickness is expanded and foamed by decomposition of the blowing agent in the composition, a decorative expanded foamed layer having an average thickness of 10 to 100 mils is produced. This is of sufficient thickness to provide satisfactory resilience and cushion effects when the product is installed as a floor covering.

The description of the invention with respect to application of the foamable composition by means of a block printing machine is not intended to restrict the invention to this method of printing. Other techniques of printing such as rotary or silk screen printing can be used. For maximum resilience in the finished product it is desirable that the printed film be of sufficient thickness that it can be expanded and foamed into a layer of appreciable thickness. Where printed films of less than 1 mil in thickness are applied, the resulting expanded film will normally be too thin to possess any appreciable properties of resilience.

After the application of the decorative foamable layer the composition must be heated to a temperature sufficient to fuse the resin and decompose the blowing agent. The temperature of the entire mass of composition upon the backing must attain the fusion temperature of the resin in order that a product of satisfactory strength is to be attained. In addition, the entire mass of foamable composition must be heated to a point where the blowing agent is decomposed. Where a preferred high temperature blowing agent is used, foaming does not occur until the resinous composition has been completely fused.

If volatile diluents are used to reduce the viscosity of the printing composition, care must be taken that they are essentially completely removed from the film prior to fusion and blowing. Otherwise poor cell structure and blister formation will result. This can be accomplished by heating the printed film at a temperature substantially below the fusion temperature and minimum decomposition temperature of the blowing agent for sufficient time to remove the volatile material. For example, if 5 percent of V. M. & P. naphtha (boiling range 190-275°) is used, heating at 200° F. for 5 minutes will remove sufficient material so that fusion and blowing 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 in a forced hot air oven as shown in the drawing or other types of heating can be used. For example, the product can be passed beneath radiant heating elements; alternately, dielectric heating can be used.

The expansion of the printed film due to foaming yields a three-dimensional 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 decorative design is unimpaired by the foaming, in that the foamed surface accurately reproduces the printed pattern applied. The decorative effect is enhanced by the three-dimensional texture present in the surface of the foamed product.

In order that the texture of the backing be accurately reproduced in the foamed product, it is important that the printed film flow into and fill all the depressions in the textured backing and become completely level so as to have a smooth surface prior to the foaming step. Where relatively thick base sheets are embossed to a substantial depth there is a possibility that satisfactory leveling of the printed film prior to foaming will not occur. With such a result the textured appearance of the final product would not accurately reproduce the pattern of the embossing. As an example, felt sheets having a thickness of 0.045 inch can be embossed to provide depressed areas having a depth of as much as 0.035 inch. In such cases improved fidelity of reproduction of the embossing in the foamed product can be attained by coating the embossed base sheet with a foamable resinous composition prior to the printing step. Doctor blade coating is a particularly effective method and insures that all the depressions in the embossed felt become completely filled with foamable composition. The coating composition used can be pigmented in a neutral color which is compatible with the general color tones desired in the finished product. After the coating step the printing composition can be applied by any of the conventional techniques or printing as already disclosed to yield a smooth uniform surface on the base prior to the foaming step. The sheet can then be passed through the foaming and fusion oven to expand the foam and form the decorative textured finished product.

Where an enhanced textured effect is desired in the finished product the foamable resinous composition used for coating the embossed felt prior to the printing step can contain a greater proportion of blowing agent than the composition used in the printing. When the composition is subjected to heat to decompose the blowing agent the composition used in coating will tend to expand to a greater extent than will the printing composition. Since the composition thickness is greater in the embossed areas of the backing than in the unembossed areas, the combination of greater thickness of foamable composition and greater degree of expansion of the foamable composition in the depressed areas will result in the production of a decorative product with an enhanced contrast between the depressed and raised areas thereof. In a modification of this technique, the textured backing sheet can be coated with a foamable resinous composition to completely cover the surface of the sheet and fill the depressions therein. A decorative design can then be applied by printing with a resinous printing composition which does not contain any blowing agent. During the heating step to fuse the resins and decompose the blowing agent in the coating, gas can migrate from the coating into the printed layer to yield a textured foamed decorative product.

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 and the spacing between the fusion oven and the end of the apparatus can be adjusted so 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.

In order to permit ease of cleaning of the product after installation it is sometimes preferred to apply a clear layer of soil resistant composition to the decorative layer. The layer of soil resistant composition can be formulated as a plastisol or organosol of a thermoplastic resin. Preferably a vinyl chloride polymer resin as described above in connection with the foamable plastisol layer is used in order to insure maximum compatibility with the decorative and foamed compositions applied to the backing. Plastisols useful as wear layers comprise from about 50 to 150 parts plasticizer per 100 parts resin. Organosols are similar to plastisols in that the resin is present in the form of fine unplasticized particles uniformly dispersed in a fluid mass. The dispersion medium in organosols comprises in addition to plasticizer a volatile organic solvent, such as xylene, toluene, cyclohexanone, methyl ethyl ketone, methyl isobutyl ketone, and the like. Organosol compositions useful in the production of soil resistant layers comprise from about 20 to about 150 parts plasticizer and about 1 to about 80 parts solvent per 100 parts resin.

Suitable soil resistant compositions are formulated in the conventional manner used in the formulation of plastisols and organosols. Since the printed decorative layer appears beneath the soil resistant composition layer it is essential that this upper layer be transparent; therefore, it is normally formulated without pigments and fillers and thus comprises fine particles of resins dispersed in compatible plasticizer in the presence of suitable heat and light stabilizers plus the addition of volatile organic solvent in the case of an organosol. After the layer of soil resistant composition is applied to the decorative surface of the foamed product the sheet is subject to heat in order to fuse the resin in the soil resistant layer and firmly bond it to the decorative foamed layer beneath.

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 resilience under foot in view of the foamed layer which is at or extremely near the surface of the product. 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 floor 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 blowing agent	2.5

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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 pigmented as desired to produce printing compositions for use in accordance with the invention, although the viscosity is too high for printing by the flat bed method.

Example II

The following ingredients in the proportions indicated were ground on a three-roll mill:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Petroleum hydrocarbon condensate ¹ -----	18
Butyl benzyl phthalate -----	52
Finely divided filler -----	3
Stabilizers -----	4
Azodiformamide blowing agent -----	3.5

¹ Conoco 300—Continental Oil Company, Ponca City, Oklahoma.

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. It was suitable for printing by the flat bed method.

Example III

The following ingredients were ground on a three-roll mill:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Petroleum hydrocarbon condensate ¹ -----	18
Butyl benzyl phthalate -----	52
Finely divided filler -----	3
Stabilizers -----	4
Azodiformamide blowing agent -----	3.5
V. M. and P. naphtha boiling range 190 to 275° F. -----	5

¹ Conoco 300—Continental Oil Company, Ponca City, Oklahoma.

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. It was suitable for printing by the flat bed method.

Example IV

The following ingredients in the proportions indicated were ground on a three-roll mill:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Didecyl phthalate -----	100
Stabilizers -----	5
Wetting agent -----	3.5
N,N'-dimethyl-N,N'-dinitroso terephthalamide blowing 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. It was suitable for printing by the flat bed method.

Example V

The following ingredients in the proportions indicated were grounded on a three-roll mill:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Didecyl phthalate -----	60
Didecyl adipate -----	25
Stabilizer -----	5
Wetting agent -----	3.5
N,N'-dimethyl-N,N'-dinitroso terephthalamide blowing 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. It was suitable for printing by the flat bed method.

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Example VI

The following ingredients in the proportions indicated were ground on a three-roll mill:

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

¹ Conoco 300—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. It was suitable for printing by the flat bed method.

Example VII

An organosol was formulated by grinding the following ingredients on a three-roll mill:

	Parts
Polyvinyl chloride (dispersion grade) -----	100
Diocetyl phthalate -----	15
Tricresyl phosphate -----	15
Petroleum mineral spirits -----	20
Methylethyl ketone -----	2
Stabilizers -----	5

Dispersion grade vinyl resin was used in the preparation of the organosol. The composition can be used as produced as a clear soil resistant layer in the production of products in accordance with the invention.

Example VIII

A sheet of felted cellulose fibers (.045 inch thick) was produced containing 5 percent by weight of the fibers of polyvinyl acetate dispersed in fine particulate form at junctions of fibers within the sheet and uniformly impregnated with 35 percent by weight of the fibers of a petroleum resin having a softening point of 120° F. The sheet was embossed to a depth of 0.020 inch in a plurality of evenly spaced depressions. The foamable plastisol composition of Example II was prepared in four separate batches, each pigmented a different color. These colored compositions were used as printing compositions in printing a four color pattern by conventional block printing technique on a surface of the felt sheet. A film having a thickness of 10 mils was printed and leveled to fill the depressions and yield a smooth surface. The sheet was then passed through an oven maintained at 400° F. with a residence time of three minutes, thereby fusing the resin and expanding and foaming the composition to produce a foamed product. The foamable compositions expanded to yield a product having a foam thickness averaging about 60 mils with a plurality of raised areas conforming in location to the embossed depressions in the backing. The product has a four color block-printed design with a three dimensional textured appearance and the presence of the foam composition results in a soft and resilient feel to the product under foot.

Example IX

To the decorative surface of product of Example VIII was sprayed a three-mil thick layer of the clear organosol of Example VII and the sheet was again passed through the 400° F. oven to fuse the organosol. The resulting clear soil resistant layer failed to detract from the resilience and appearance of the product but rendered it more easily cleaned and resistant to soiling when the product was subjected to foot traffic.

Example X

A sheet of felted cellulose fibers having a thickness of 0.045 inch containing 5 percent by weight of the fibers of polyvinyl acetate dispersed in fine particulate form

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at junctions of fibers within the sheet and uniformly impregnated with 35 percent by weight of the fibers of a petroleum resin having a softening point of 120° F. The sheet was embossed to a depth of 0.030 inch to provide a plurality of evenly spaced depressions in the surface of the felt. The foamable plastisol composition of Example VI was prepared and pigmented in a neutral color. The foamable plastisol composition of Example II was prepared in four separate batches, each pigmented a different color in accordance with the colors desired in the finished product. The pigmented 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. The four pigmented batches of the plastisol composition of Example II were used as printing compositions in printing a four color pattern by conventional block printing technique on the surface of the felt bearing the depressions filled with the pigmented plastisol of Example VI. A printed film having a thickness of 10 mils was produced. The printed film had a smooth and level surface. 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 blowing 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 textured appearance of the product was greater than that of the product of Example VIII due to the deeper embossing of the backing and the larger proportion of blowing agent in the plastisol used in filling the embossed depressions. The finished product has a four color block printed design with a highly textured surface as a result of the raised foamed areas. The presence of the foam over the entire surface of the product imparts a high degree of resilience to the product.

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

I claim:

1. A decorative surface covering which comprises a flexible sheet having in one surface a plurality of areas depressed at least 5 mils beneath said surface and a layer of expanded and foamed plasticized thermoplastic resinous composition in the form of a decorative printed design covering said surface and adherent thereto, said layer having a plurality of raised portions overlaying and conforming in character and spacing to said depressed areas in said surface.

2. A decorative surface covering which comprises a flexible sheet having in one surface a plurality of areas depressed at least 5 mils beneath said surface and a layer of expanded and foamed plasticized vinyl chloride polymer composition in the form of a decorative design printed upon and covering said surface, said layer having a plurality of raised portions overlaying and conforming in character and spacing to said depressed areas in said surface.

3. A decorative surface covering which comprises a flexible impregnated felted fibrous sheet having one surface embossed to provide a plurality of areas depressed at least 5 mils beneath said surface and a layer of expanded and foamed plasticized vinyl chloride polymer composition in the form of a decorative design printed upon and covering said surface, said layer having a plurality of raised portions overlaying and conforming in character and spacing to said depressed areas in said embossed surface.

4. A decorative surface covering which comprises a flexible impregnated felted fibrous sheet having one surface embossed to provide a plurality of areas depressed at least 5 mils beneath said surface and a layer of expanded and foamed plasticized vinyl chloride polymer

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composition comprising 50 to 150 parts plasticizer per 100 parts vinyl chloride polymer in the form of a decorative design covering said surface and adherent thereto, said layer having a plurality of raised portions overlaying and conforming in shape and spacing to said depressed areas in said embossed surface.

5. A decorative surface covering which comprises a flexible impregnated felted fibrous sheet having one surface embossed to provide a plurality of areas depressed at least 5 mils beneath said surface and a layer of expanded and foamed plasticized vinyl chloride polymer composition comprising 50 to 150 parts plasticizer per 100 parts vinyl chloride polymer, said vinyl chloride polymer having a specific viscosity between 0.17 and 0.31, said layer being in the form of a decorative design printed on and covering said surface and having a plurality of raised portions overlaying and conforming in shape and spacing to said depressed areas in said embossed surface.

6. A decorative surface covering which comprises a flexible impregnated felted fibrous sheet having one surface embossed to provide a plurality of areas depressed at least 5 mils beneath said surface and a layer of expanded and foamed plasticized vinyl chloride polymer composition comprising 60 to 100 parts vinyl chloride polymer, said vinyl chloride polymer having a specific viscosity between 0.17 and 0.31, said layer being in the form of a decorative design printed on and covering said surface and having a plurality of raised portions overlaying and conforming in shape and spacing to said depressed areas in said embossed surface.

7. A decorative surface covering which comprises a solid flexible sheet having on one surface a plurality of areas depressed at least 5 mils beneath said surface and a layer of expanded and foamed plasticized thermoplastic resinous composition covering said surface and adherent thereto, said layer having a plurality of raised portions overlaying and conforming in character and spacing to said depressed areas in said surface.

8. A method of producing a decorative surface covering which comprises printing upon a surface of a flexible sheet to form a decorative design a liquid foamable thermoplastic resinous composition containing an effective amount of a blowing agent, said surface having a plurality of areas depressed at least 5 mils beneath said surface, said composition completely covering said surface and filling said depressed areas therein and heating said composition printed on said surface to fuse said composition and decompose said blowing agent thereby expanding said composition to create a textured decorative foamed surface which bears a plurality of raised areas which conform in shape and position to the depressed areas in said surface of said flexible sheet.

9. The method according to claim 8, wherein said foamable thermoplastic resinous composition has a viscosity between 200 and 25,000 centipoises at 20° C.

10. The method according to claim 9 wherein said foamable thermoplastic resinous composition is a foamable plastisol of vinyl chloride polymer comprising 50 to 150 parts plasticizer per 100 parts vinyl chloride polymer.

11. A method of producing a decorative surface covering which comprises printing upon an embossed surface of an impregnated felted fibrous sheet to form a multicolored decorative design a foamable vinyl chloride polymer plastisol composition, said embossed surface having a plurality of areas depressed at least 5 mils beneath said surface, said composition having a viscosity between 200 and 25,000 centipoises at 25° C. and comprising 50 to 150 parts plasticizer per 100 parts of vinyl chloride polymer and an effective amount of a blowing agent which can be decomposed by heating to a temperature of less than about 450° F., said composition completely covering said embossed surface and filling the depressions therein and heating said composition printed upon said surface to a temperature sufficient to fuse said

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vinyl chloride polymer and to decompose said blowing agent, thereby expanding said composition to create a three-dimensional textured decorative foamed surface which bears a plurality of raised areas which conform in shape and position to said depressed areas in said embossed surface of said felted fibrous sheet.

12. The method according to claim 11 wherein said vinyl chloride polymer has a specific viscosity of between 0.17 to 0.31.

13. The method according to claim 11 wherein said blowing agent has a minimum initial decomposition temperature of at least about 200° F.

14. A method of producing a decorative surface covering which comprises embossing a surface of a sheet of felted fibers impregnated with a moisture proofing and strengthening impregnant to create a plurality of areas depressed at least 5 mils beneath said surface, printing upon said surface to form a multicolored decorative design a vinyl chloride polymer plastisol composition to completely fill said depressed areas and to cover said surface with a smooth printed layer, said vinyl chloride polymer plastisol composition having a viscosity between 500 and 5,000 centipoises at 25° C. and comprising 50 to 150 parts plasticizer and about 1 to about 20 parts blowing agent per 100 parts vinyl chloride polymer, said blowing agent being decomposed by heating to a temperature of less than about 450° F., and heating said composition layer printed on said embossed surface to fuse said composition and decompose said blowing agent thereby expanding and foaming said printed composition layer to create a decorative textured foamed surface which bears a plurality of raised areas which conform in shape and position to said depressed areas in said embossed surface of said sheet.

15. The method according to claim 14 wherein said vinyl chloride polymer has a specific viscosity between 0.17 and 0.31.

16. A method of producing a decorative surface covering which comprises block printing upon a surface of a flexible sheet having a plurality of areas depressed at least 5 mils beneath said surface a foamable vinyl chloride polymer plastisol composition to completely fill said depressed areas and to cover said surface with a smooth printed layer having a thickness of about 5 to about 10 mils over said surface to form a multicolored decorative design, said composition having a viscosity between 1,000 and 3,500 centipoises at 25° C. and comprising 60 to 100 parts plasticizer and 2 to 10 parts blowing agent per 100 parts vinyl chloride polymer, said blowing agent having a minimum initial decomposition temperature of at least about 200° F. and being decomposed by heating to a temperature of less than about 450° F., said vinyl chloride polymer having a specific viscosity of 0.17 to 0.31, and heating said composition layer printed upon said embossed surface to a temperature sufficient to fuse said vinyl chloride polymer and to decompose said blowing agent thereby expanding said printed composition layer to create a decorative textured foamed surface which bears a plurality of raised areas which conform in character and spacing to said depressed areas in said surface of said sheet.

17. The method according to claim 16 wherein there is applied to said decorative textured foamed surface a clear layer of soil resistant composition selected from the group consisting of plastisols and organosols of vinyl chloride polymer and said clear layer is heated to fuse said polymer in said clear layer and to bond said clear layer to said foamed surface.

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18. The method according to claim 16 wherein said blowing agent has a minimum initial decomposition temperature of at least the fusion temperature of said vinyl chloride polymer.

19. The method according to claim 18 wherein said blowing agent is azodiformamide.

20. A method of producing a decorative surface covering which comprises printing upon a surface of an impregnated felted fibrous sheet a foamable vinyl chloride polymer plastisol composition to form a decorative multicolored design, said surface having a plurality of areas depressed at least 5 mils beneath said surface, said composition having a viscosity between 200 and 25,000 centipoises at 25° C. and comprising 50 to 150 parts plasticizer and up to 10 parts volatile diluent per 100 parts vinyl chloride polymer and an effective amount of a blowing agent which can be decomposed by heating to a temperature of less than about 450° F., heating said printed composition to a temperature below the fusion temperature of said polymer and below the minimum decomposition temperature of said blowing agent to substantially completely evaporate said volatile diluent and thereafter heating said printed composition to a temperature sufficient to fuse said polymer and to decompose said blowing agent thereby expanding and foaming said printed composition to create a decorative textured foamed surface which bears a plurality of raised portions which conform in shape and position to said depressed areas in said surface of said sheet.

21. A method of producing a decorative surface covering which comprises coating a surface of a flexible sheet having a plurality of areas depressed beneath said surface with a first foamable vinyl chloride polymer plastisol composition to completely fill said depressed areas, printing upon said surface having said depressed areas filled with said first plastisol composition a second foamable vinyl chloride polymer plastisol composition to form a decorative multicolored design having a uniform thickness of about 5 to about 10 mils over said surface, said first and said second plastisol compositions having viscosities between 200 and 25,000 centipoises at 25° C. and comprising 50 to 150 parts plasticizer and 1 to 20 parts blowing agent per 100 parts vinyl chloride polymer, said blowing agent being decomposed by heating to a temperature of less than about 450° F., and heating said compositions applied to said surface to a temperature sufficient to fuse said vinyl chloride polymer and to decompose said blowing agent in said compositions thereby expanding and foaming said compositions to create a decorative textured foamed surface which bears a plurality of raised areas which conform in shape and position to said depressed areas in said surface of said flexible sheet.

22. The method according to claim 21 wherein the ratio of blowing agent to polymer in said first plastisol composition is greater than the ratio of blowing agent to polymer in said second plastisol composition.

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