

May 26, 1959

C. H. BURCHENAL ET AL

2,887,867

TILE ASSEMBLY ON BACKING

Filed Sept. 30, 1957

2 Sheets-Sheet 1

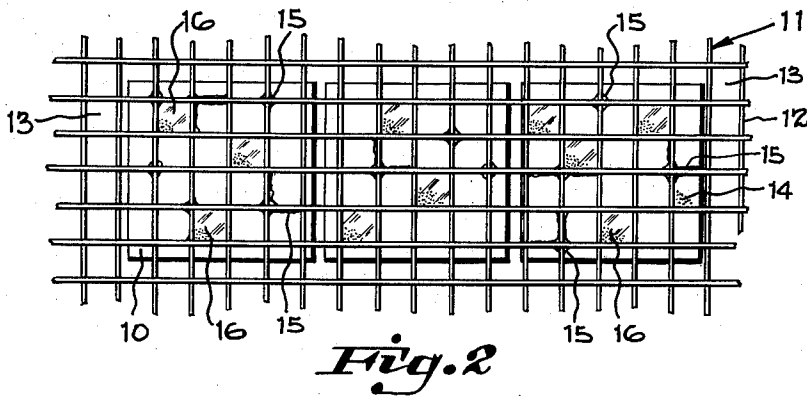
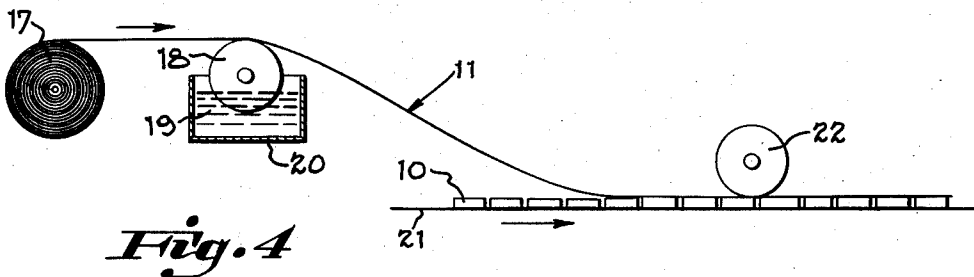
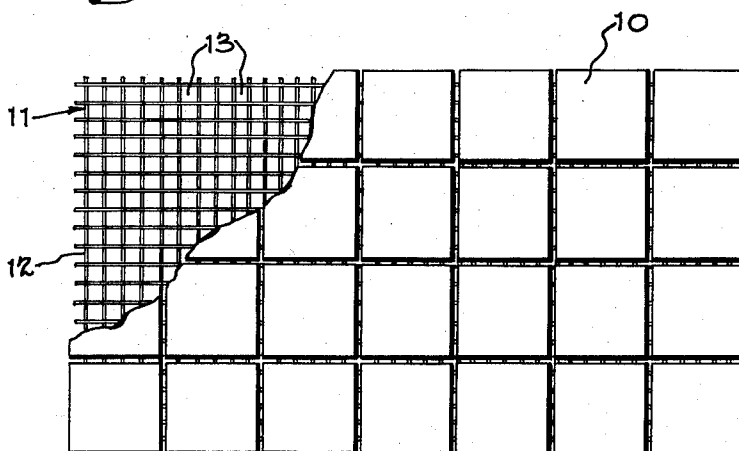


Fig. 3

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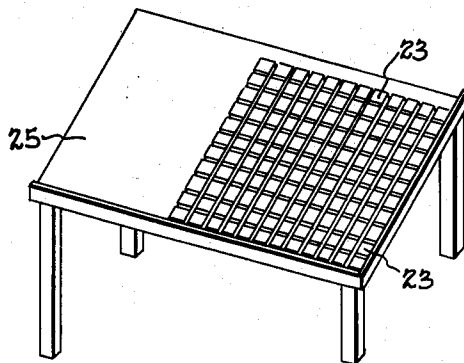


Fig. 5

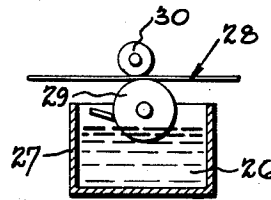


Fig. 6

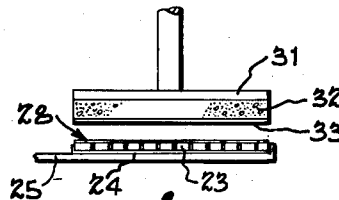


Fig. 8

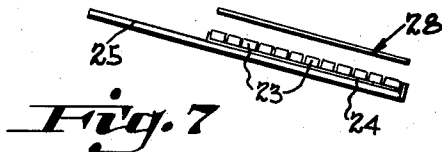


Fig. 7

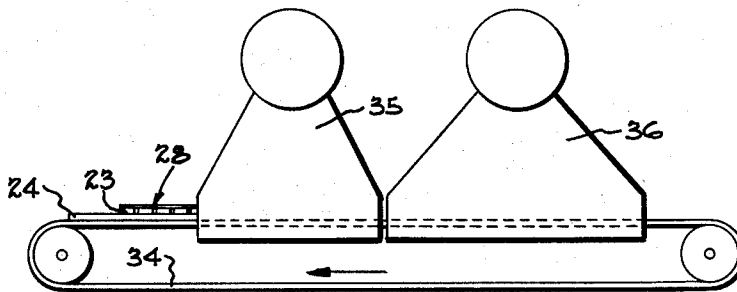


Fig. 9

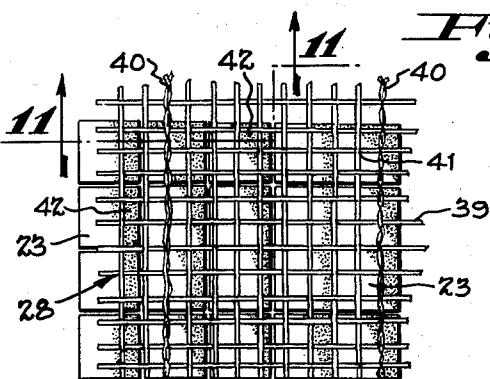


Fig. 10

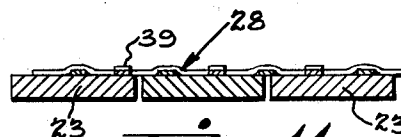


Fig. 11

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2,887,867

TILE ASSEMBLY ON BACKING

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Application September 30, 1957, Serial No. 687,292

8 Claims. (Cl. 72-22)

This invention relates to ceramic tile. The invention is particularly directed to a form of tiling adapted for installation upon floors or walls wherein individual pieces of tile arranged in spaced relation to one another in a predetermined pattern or order are mounted upon a fabric backing through which the installation of the tiles upon the floor or wall base or sub-surface is facilitated and reliable bonding of the tiles thereto is obtained.

A principal objective of the invention has been to provide an improved tile assembly by means of which a more perfect bond is achieved between the tile and the wall or floor surface upon which it is installed. Briefly, the product of this invention comprises individual pieces of tile adhered at their back faces to a fabric sheet material in a spaced pattern or arrangement such that the sheet of tiles, as a unit, may be bonded to a wall or floor surface either by means of an organic or inorganic cement, as chosen at the option of the tile setter. The improvements of the present invention relate to the manner in which the more perfect bond is obtained through the use of one or another of the commonly available organic or inorganic cements. However, in understanding the nature of the present improvements, a brief description of conventional procedure in tile setting is helpful.

In a typical procedure which has been employed for many years, tile manufacturers have sold tiling sections in which the faces of tile pieces arranged in a desired pattern are adhered temporarily, i. e., until installation, such as by means of water-soluble glue, to a sheet of paper. With the sheet of paper uppermost, the tiles of the section are then adhered by the tile setter to a sub-surface by means of an organic cement such as mastic or an inorganic cement such as Portland cement mortar. The sheet of paper, to which the faces of the tiles are adhered, is then dampened with water until the adhesive is softened sufficiently to permit removal thereof from the tiles. Subsequently, the spaces between the individual pieces of tile, now adhered to the subsurface by the bonding cement, are filled with a material called grouting to complete the installation. The grout is usually neat cement, comprising essentially a mixture of Portland cement and water, although sometimes an inert additive is included. So-called "self-curing" inorganic cement mixed with water is sometimes used as grouting, and neat or self-curing cement is sometimes used in place of mortar for bonding the tiles to the wall or floor sub-surface. The sub-surface or base upon which installation of the tile is made may be mortar, plaster, masonry, plywood, wall board or the like.

In some localities of the country, organic cement or mastic is preferred as the principal bonding medium between the back of the tile and the sub-surface, while in other areas the inorganic type of cement is preferred; the choice seems to be mainly a matter of habit or local building custom. With either of these materials the bond between the tile and the sub-surface is less perfect and less permanent or durable than is desirable. Organic or mastic bonding materials, mostly through deteriorative

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chemical changes or embrittlement, lose adhesive properties with time, and pieces of tile break loose. On the other hand, inorganic or Portland-type cements depend upon water evaporation and hydration or crystallization phenomena in setting to a hard condition, because of which shrinkage effects are encountered which may cause bond rupture. Failure of either type of bond may occur shortly after installation or progressively over the years, but the result is always troublesome because the fault is so conspicuous when it occurs and because replacement of separated tile provides no assurance that others will not soon come loose.

More recently, instead of placing the faces of tiles upon a sheet in fabrication of a tiling section, it has been proposed to place a mounting sheet over the back surface of the tile pieces in order that the pattern or design of the tiles would not be obscured while the tiles are being placed upon the subsurface and in order that the need for subsequent removal of the sheet before grouting would be eliminated. However, this technique, while facilitating the mechanics of installation, has not provided bonding which is any more permanent or satisfactory than the other method either with the use of organic or inorganic cement mediums; in fact, bonding by the latter method has been generally less satisfactory.

In accordance with the present invention, a tiling section is provided wherein individual pieces of tile are adhered to a foraminous backing fabric by means of an elastomeric or flexible adhesive which not only secures the tile to the backing but forms a bond supplemental to the bond through which the tile itself is secured to the subsurface, whether the latter bond be constituted by an organic cement or mastic, or by an inorganic medium such as mortar or neat cement. Further improvements of the present invention reside in the provision of a fabric backing which itself is dimensionally stable in the presence of water or moisture and in adhesion of the tile to the fabric backing by means of an adhesive which is not only elastomeric or yieldable but which itself is stable and adherent to the bonding medium in the presence of water such as the water contained in typical bonding mediums used in conventional ways. Thus, the dominant idea of the present invention is the provision of a reliable, durable, multiple bonding effect between the individual tile pieces of the pre-arranged sheet of tile pieces and the wall or floor sub-surface on which they are laid. Otherwise expressed, the present invention provides a multiple bonding effect characterized by not only the usual tile-to-cement bond, but also by durable, flexible bonding of cement to adhesive to tile which is not disrupted by the dimensional instability of the cement or sub-surface on which the tiles are installed.

In our co-pending application Serial No. 515,676, filed June 15, 1955, and now abandoned, entitled "Ceramic Tile and Bonding Method," of which present application is a continuation-in-part, one method of approximating the result of the present invention has been disclosed. According to the disclosure of the co-pending application, the backs of the individual tile pieces, arranged in the desired pattern, are secured to an open mesh fabric by means of an elastomeric adhesive which has been coated over a face of the open mesh fabric. The coating may be accomplished by dipping, spraying, or rolling, or by application of the adhesive as a hot melt which hardens or sets upon cooling, and the adhesive may be applied as a solution in a volatile solvent or as an emulsion. A plasticized polyvinyl acetate emulsion has been found satisfactory for the practice of the invention, so the disclosure of the co-pending application is made primarily in respect to that type of adhesive. The polyvinyl acetate may be plasticized with 5 to 50% of any of the usual plasticizers for it, including alkyd type resins, dibutyl

phthalate, glycol esters, tricresyl phosphate, chlorinated polyphenyls or the like. In coating, depending upon the nature of the fabric and the adhesive, a "windowing" effect occurs over as much as 50% of the openings of the backing, thereby furnishing a layer of adhesive having one of its faces engaging the back of the tile and the other of its faces engageable by and bondable to the bonding medium or cement, whether organic or inorganic, through which the tiling section is secured to a floor or wall sub-surface.

A tiling section comprising the sheet of pre-arranged tile which results from such a process has a double bonding action when the sheet is set. There are local areas on the back of each individual tile piece which are coated with the polyvinyl acetate, and there are also areas which are not coated. The mesh of the backing web may be substantially $\frac{1}{16}$ of an inch or more, depending on the size of the tile and, when the tile pieces are pressed in pre-arranged order on the mesh web, the adhesive tends to spread somewhat upon the tile thereby exposing adhesive beyond the strands of the backing for engagement by the cement. The result is a sheet of pre-arranged tile which is adapted to provide a double bond when set either in an organic type cement or an inorganic type, as desired by the tile setter. Thus, in installing the tile section to a sub-surface, cement bonds directly to the areas of the tile backs not covered by the strands of the backing fabric or by the windowed adhesive. Cement also bonds to the strands of the mesh, to the windowed adhesive at the areas beyond the strands if or when such are present, and to adhesive exposed at the peripheries of the mesh openings where windowing has not occurred. If the primary bond between the tile and the cement is disrupted, such as for reasons which are subsequently discussed in more detail, a supplemental or insurance bond is still maintained at the areas where the cement engages the strands or engages the adhesive adhered to the tile. The tile pieces thereby are held in place even though the primary bond between the tile and the cement is ruptured through deterioration of the cement or through uneven or differential contraction of the sub-surface wall or floor structure.

This supplementary bond is a much more flexible bond than the primary bond; the modulus of elasticity of the adhesive material selected to adhere the tile to the backing is below 500,000 pounds per square inch in comparison with at least approximately 2,000,000 pounds per square inch for hardened cement or mortar. Hence, the supplementary bond holds the individual tile pieces in place even under conditions which deteriorate the primary bond between the cement and the ceramic tile. In this manner, multiple bonds are provided between the cement and the tile so that the installation has far greater durability or permanency than the tile installations which have been made in the past.

An important improvement of the present invention, wherein it differs from the improvement disclosed in the aforesaid co-pending application, resides in the provision of a tiling section which is dimensionally stable in the presence of water or moisture and in the provision of an elastomeric adhesive which is indifferent to moisture exposure such that the multiple bonding effect previously described is realized in conjunction with the elimination of the dimensional changes which would be caused by the presence of water during installation. Where the tile setter chooses an inorganic cement such as mortar or neat cement as the bonding medium for mounting the tiling sections to a sub-surface, water, of course, is present in substantial quantity since water is required in the preparation and to enable hydration and hardening of the Portland cement component of that kind of bonding medium. On the other hand, where an organic cement is chosen, the commercially available mastics frequently are in the form of water-made emulsions. While the invention is disclosed in relation to its ability to meet the conditions most adverse to stability as represented by

the water present in a neat cement installation, the tiling sections of the present invention are equally satisfactory for use where the tile setter chooses a less water-laden mortar, a water-emulsion type mastic, or an organic solvent type mastic as the bonding medium. Thus, in accordance with this invention, a dimensionally stable foraminous backing is employed in conjunction with an adhesive securing the tile to the backing which is not adversely affected by moisture and which itself is capable of providing upon installation of the section an elastic or flexible bond to the tile at the one side and to an organic or inorganic bonding medium at the other.

The mesh or foraminous sheet backing of this invention may be constituted by any desired strands or fibers having the properties indicated, either woven or fabricated by other suitable means. A very satisfactory fabric, for example, is one woven from paper formed into strands either by twisting or folding of paper strips. Fabric constituted of paper, for example kraft paper suitably treated for dimensional stability, has adequate strength plus the advantage that it is cheap and the further advantage that the strands, which may be relatively uneven when formed by twisting, may be flattened or crushed after weaving to provide a greater area of surface contact with the back of the tile than would be possible if the fabric were fashioned of strands inherently smooth and circular in cross-section. For such reasons, foraminous mat woven of paper is disclosed as a preferred embodiment of the backing which is used in the practice of this invention, but dimensionally stable mat fabricated from other materials including synthetic materials or even glass fibers may be used. When a fabric is selected comprising strands of fibers which are normally responsive to water, or fibers or strands which shrink or expand appreciably when wetted, it is desirable to size or impregnate the fibers or strands thereof with an agent which will reduce the water responsivity and render the same dimensionally stable. In general, especially for installations where uniformity of inter-tile spacing is to be preserved, the backing sheet as used should not shrink substantially more than $\frac{1}{16}$ of an inch in two feet after immersion in water and preferably not more than $\frac{1}{32}$ of an inch in two feet.

To secure the back faces of the tile pieces to the backing fabric, an adhesive is employed which is flexible or elastomeric and has a lesser modulus of elasticity than the cement used to mount the tiling sections to a wall or floor sub-surface and which is compatible with or bondable to both organic and inorganic cements of the type commonly used for bonding tile to sub-surfaces. The adhesive preferably should also be insensitive to water so as to at least maintain its adhesive and cohesive properties in the presence of water such as it might encounter in water-made organic or inorganic bonding mediums during the installation, or the moisture which might later be absorbed from the atmosphere or environment. A preferred adhesive adapted to be used in the practice of the invention comprises polyvinyl acetate emulsion in which a thermo-setting resin such as melamine formaldehyde resin is incorporated. Such a composition also may be employed as a sizing or impregnating agent for the backing sheet, whereby dimensional stability is conferred upon the backing sheet and coherence of the adhesive thereto is assured when the backing sheet is adhered to the tile pieces. However, in place of polyvinyl acetate adhesive containing melamine formaldehyde resin additive, other adhesives may be used in the practice of the invention, such as polyvinyl acetate plus urea formaldehyde (e.g., Paisley Products Company's #363 adhesive plus #364 additive), acrylic adhesive (e.g., Rohm and Haas Company's #AC-33), neoprene latex adhesive (e.g., H. B. Fuller Company's #3-1-57), natural rubber latex adhesive (e.g., U.S. Rubber Company's Laticrete liquid #10-33), reclaimed rubber emulsion (e.g., J. G. Milligan Company's #5699), solvent type adhesive (e.g., Du Pont Company's #4678), and poly-

vinyl acetate adhesives containing phenolic additive (e.g., Synco Company's resins #935, #991, or #993 with accelerators 9, N, P, 29, or 30). In general, it should be noted that phenolic additives may cause an alkaline grout to become stained when subsequently applied to the spaces between the tiles, which may be undesirable unless a dark-colored grout is used. When the adhesive or additive thereto is of the thermo-setting type of resin, as is the case with the preferred polyvinyl acetate emulsion-melamine formaldehyde resin, heat is applied to the backing fabric or to the backs of the tile pieces or both as necessary to cause the adhesive and sizing incorporated in the backing to become properly set or cured. In general, the incorporation of a thermo-setting resin, particularly melamine formaldehyde in the elastomer component of the adhesive or impregnant, improves water resistance.

In general terms the preferred practice of the method or process of this invention in preparing the tile sections involves the following steps:

(1) Paper, such as a strip of kraft paper approximately one-half inch wide, is twisted or spun to produce a yarn.

(2) The yarn is woven into an open mesh fabric.

(3) The fabric is treated with water resistant sizing material.

(4) The fabric is crushed to flatten the strands.

(5) The fabric is coated with a flexible adhesive which, if moisture-sensitive by itself, contains a resin additive rendering the same substantially insensitive to water.

(6) The tile pieces are set in a mounting board with the backs of the tile pieces exposed.

(7) The backs of the tile pieces on the mounting board are pressed into engagement with the adhesive with which the fabric is coated.

(8) The resin of the adhesive and sizing is set or cured by suitably elevating the temperature of the fabric or adhesive or both.

(9) The assembly is cooled.

The tiling sections produced by this general method are now ready for installation and may be set in inorganic cement, i.e., mortar or neat cement, or organic cement, i.e., conventional mastic, whether or not of the emulsified type.

The preferred practice of the present invention is illustrated more specifically as follows: kraft paper one-half inch wide weighing approximately 20 pounds per ream, is passed through a water bath to soften the same to facilitate its fabrication into yarn and fabric, and it is then twisted to produce yarn which is wound on spools and allowed to dry. The yarn is then woven into an open mesh fabric having approximately 3 or 4 strands to the inch. The weave is preferably an over-under weave, although Leno strands may be incorporated if desired—for instance, one Leno pair for 8 single strands of warp.

Preferably, the open mesh fabric is woven as a continuous web of about 5 feet wide. After the fabric is woven, it is passed through a sizing tank, containing suitable water-resistant sizing such as the resin previously disclosed, in which the fabric picks up about 22 pounds of sizing solids for every 100 pounds of fabric. After the woven fabric is dry, it is passed between pressure rollers to flatten the strands of the fabric. If desired, the strands may be flattened to approximately one-half of their original thickness, which increases the area of engagement between the flattened faces of the strands and the backs of the tile pieces. In general, the initial dimension of the strands may be of the general order of $\frac{1}{16}$ to $\frac{1}{32}$ of an inch, and the strands may be flattened out to a thickness of $\frac{1}{40}$ of an inch or less. The waterproofing resin strengthens the fabric by adhering the strands together where they cross and by binding the individual fibers of the strands so as to stiffen the backing sufficiently that a tiling section will not be too limp to handle when a

plurality of the relatively heavy pieces of tile are adhered to the backing sheet.

For application to the tiles, the backing material is cut into sheets of a size suitable to produce tiling sections which are convenient to handle, for example, 2 feet long and 1 foot wide. With the tiles mounted thereon such sections will weigh approximately 8 pounds more or less, depending upon the thickness of the tile.

The spacing of the strands of the backing sheet from one another or the number of openings per square inch of backing sheet will depend upon the size of the individual pieces of tile which are to be adhered thereto. Thus, a backing sheet approximately 2 feet long and 1 foot wide with tile mounted on it is sufficiently stiff and stable to facilitate handling and transportation during manufacture, storage, and packing and to facilitate the handling which is requisite to the laying of the sheet.

In this regard, it is generally desirable to expose at least 40% of the area of the back of the tile piece to the material in which it is set, but this open area may be increased to as high as 90% where the tile pieces are relatively large. As a typical example, for use in conjunction with pieces of square tile approximately $\frac{3}{4}$ of an inch or 1 inch on each side, the strands may be spaced at intervals of from 2 to 6 per inch. Similar strand spacing may be used where the tiles are much larger. It is also to be noted that neither the diameters nor the spacing of the warp and woof strands need be uniform; the warp may be constituted by strands which are relatively thick and widely spaced in comparison with the woof strands, or vice versa.

Although various resinous materials may be employed to waterproof the mesh fabric to render it water-resistant and hence dimensionally stable, and also to attach the backs of the tile pieces to the fabric, we prefer to use for both purposes a mixture of materials which includes the previously indicated polyvinyl acetate emulsion. For example, suitable polyvinyl acetate emulsions may be purchased on the open market containing, in general, approximately 55% solids. One or more plasticizers may be used, such as: N-ethyl ortho and para toluene sulfonamide, triphenyl phosphate, dibutyl phthalate, butyl phthalyl butyl glycolate, methyl phthalyl ethyl glycolate or other suitable material.

The following is a typical adhesive formula for adhering tile to backing using a polyvinyl acetate emulsion:

	Percent by wt.
Polyvinyl acetate emulsion (55% solids by weight) -----	65- 90
Plasticizer -----	8- 30
Melamine formaldehyde resin -----	25- 5
Stabilizer -----	0-1.5
Wetting agent -----	0- .5
Defoamer -----	0-1.5

The following is a typical formula for sizing, stabilizing, or impregnating fibrous organic or inorganic backing sheets, mesh, or woven materials:

	Percent by wt.
Polyvinyl acetate emulsion (55% solids by weight) -----	40- 50
Plasticizer -----	5- 20
Melamine formaldehyde resin -----	25- 5
Stabilizer -----	0-1.5
Wetting agent -----	0- .5
Water -----	40- 50
Defoamer -----	0-1.5

The preferred combination of polyvinyl acetate emulsion and melamine formaldehyde resin which we employ is very satisfactory for the purposes set forth in that the two components are entirely compatible with each other at the percentages used, develop tackiness sufficiently rapidly, may be handled by spraying or by rollers, and may be set to a water-resistant, cement-compatible

composite by a low temperature thermal treatment which is not injurious to the fabric backing.

In place of the preferred adhesive and sizing compositions just given, and supplemental to alternative compositions previously identified by trade name, the following formulations illustrate combinations adapted to be used in the practice of this invention (the percentages given being by weight):

Example A

	Percent
Acrylic resin emulsion (40-46% solids) -----	65- 90
Plasticizer -----	8- 30
Filler (Clay on micro ground calcium carbonate) -----	0- 15
Stabilizer -----	0-1.5
Wetting agent -----	0- .5
Defoamer -----	0-1.5

Example B

Natural rubber latex (45-50% solids) -----	85- 98
Antioxidant -----	1- 2
Curing agent -----	.1- .2
Filler -----	0- 15
Ammonium hydroxide sufficient to raise pH to 8.5.	

Example C

Reclaimed rubber emulsion (50-55% solids) ---	80- 90
Antioxidant -----	1- 2
Curing agent -----	.1- .2
Filler -----	0- 15

Example D

Neoprene latex (50-55% solids) -----	85- 98
Plasticizer -----	0- 10
Wetting agent -----	0- .5
Defoamer -----	0-1.5
Filler -----	0- 15

Example E

Polyvinyl acetate emulsion (55% solids) -----	65- 90
Plasticizer -----	8- 30
Urea formaldehyde -----	.5- 5
Stabilizer -----	0-1.5
Wetting agent -----	0- .5
Defoamer -----	0-1.5

The foregoing products may be dissolved in organic solvents to provide 20-25% by weight solids concentration. For use as sizing more or less solvent may be used depending upon the nature of the fibers in the backing sheet which is to be sized and the sizing composition selected.

In summery, the backing sheet of this invention is a foraminous sheet or lattice which is rigid in its own plane but flexible transversely. Otherwise expressed, the positions of the backing sheet between the points of attachment to different tile pieces is sufficiently unyieldable in the plane of the backing sheet to sustain the weight of the mounted tile pieces under compression and to maintain the predetermined spacing of the tile pieces during the tile setting operation and the handling which is incidental thereto. If the lattice is constituted by strands then all areas of the strands between points of attachment to different tile pieces, while relatively flexible transversely, are sufficiently stiff and axially unyieldable to sustain the weight of the tile pieces under compression and to maintain the selected relative position of the tile pieces during the tile laying operation and the handling which is incidental thereto.

The backing sheet is also dimensionally stable in the presence of water or moisture. If the strands of the lattice are not constituted of materials or fibers, such as glass fibers for instance, which are not in and of themselves impervious to water, then the strands are sized or impregnated with an elastomeric adhesive type of

material which renders the strands water-resistant and also stiffens them.

In the preferred lattice of the invention the strands are constituted by a yarn of twisted kraft paper which is waterproofed and strengthened by impregnation with a water-resistant, elastomeric adhesive. The individual tiles are secured to the lattice by an elastomeric adhesive which bonds with Portland cement so that when the tile sheet is set in Portland cement mortar of the type used for tile setting, each tile piece is supported in the plane at right angles to its face by a series of cement platforms which are defined and separated from one another by a lattice of elastomeric bonds.

Other objects and further advantages of the invention are disclosed in the following description of the accompanying drawings in which:

Figure 1 is a side elevation of an assembly of tiles mounted on a mat woven of strands, such as is disclosed in our co-pending application Serial No. 515,676;

Figure 2 is a plan view looking at the back of the sheet shown in Figure 1;

Figure 3 is a plan view, partly broken away, looking down on the face of a sheet of mounted tile;

Figure 4 is a diagrammatic view showing a method by which a continuous strip of mounted tile of the type shown in Figures 1, 2, and 3 may be fabricated;

Figures 5 through 9 are diagrammatic views showing a preferred method by which individual sheets of mounted tile in predetermined dimensions may be fabricated, in which views:

Figure 5 is a perspective view of a mounting board resting on an easel with tiles spotted on the mounting board awaiting application of the backing sheet;

Figure 6 is a diagrammatic view showing a method by which the adhesive may be applied to the individual sheet of backing;

Figure 7 is a side elevation showing a mounting board resting on an easel and a mat positioned to be applied to the tiles;

Figure 8 is a side elevation showing the mat ready to be pressed onto the tile;

Figure 9 is a diagrammatic view of the conveyORIZED heating and cooling system in which the adhesive on the assembly is set and cured;

Figure 10 is a plan view looking at the back of the sheet made with an improved mat differing from that shown in Figures 1 and 2 in that it is made of flattened oval-shaped fibers; and

Figure 11 is a section through line 11-11 of Figure 10 showing the flattened cross-section of the mat fibers made according to the improvement.

Referring to Figures 1, 2, and 3 with more particularity, a plurality of individual tiles 10 are secured to a mesh fabric backing web or sheet 11. The latter, as disclosed in our copending application, is constituted by textile strands 12 substantially .028 inch thick with 6 picks per inch, woven to provide opening 13. The individual tile pieces are secured to the mesh fabric backing 11 by a film 14 of polyvinyl acetate adhesive between the threads of the mesh fabric and the backs of the tile pieces. There are also polyvinyl acetate films on the backs of the individual tile pieces by reason of spread of the adhesive on some of the threads, as at 15, and windowing between strands of the mesh as at 16. These polyvinyl films 15 and 16 are deposited on the backs of the tile pieces during the fabrication of the pre-arranged tile sheet.

Although the mounted tile sheet of this invention may be made by utilization of many types of equipment, one method of making the same in continuous lengths is disclosed in Figure 4. A bolt 17 of mesh backing fabric is disposed on a mandrel (not shown) and is drawn continuously over roller 18 which is partly submerged in adhesive 19 in container 20 to coat one face of the mesh web with adhesive. The pieces of

tile 10 are arranged on a continuously moving endless conveyor 21 which carries the individual tile pieces under a pressure roller 22. The backing web is interposed between the pressure roller and the backs of the tile pieces so that the web is adhesively secured to the backs of the tile pieces, and the adhesive is coincidentally disposed over areas of the backs of the tile pieces other than the immediate areas covered by the strands of the mesh fabric. The web may then be cut into individual sheets of suitable dimension.

Sheets of mounted tile of predetermined size may be fabricated individually according to a preferred method which is disclosed in Figures 5 through 9. The process of assembly starts with individual tiles 23 which are spotted in a frame 24 (Figure 7) with or without dividers, commonly called a mounting board. The board may be rested on a slanting easel 25 to facilitate spotting and locating the tiles uniformly within the gridwork. Attachment of tiles to a backing material provides a flexible but tight permanent bond which prevents the individual tiles from being further adjusted or aligned during on-the-spot installation of the fabricated sheets. Therefore, it is necessary that the proper spacing and alignment be completed before the next step in the process is begun. The outer dimensions of the gridwork on the mounting board determine the size of the sheet of mounted tile, and the spacing of the dividers relative to the size of the tile or spacing lugs on the tile pieces determines the inter-tile spaces to be filled with grout during installation. These dimensions are, in turn, predetermined by such considerations as the size and shape of individual tiles, and the pattern in which they are arranged.

The adhesive is applied to a pre-cut mat as is shown in Figure 6. Adhesive 26 in a container 27 is applied to the mat 28 by a cylindrical roller 29 axially rotatable which dips into the container and is partially immersed in the adhesive. The roller applies the adhesive to the lower surface of the mat at the tangential point of contact, the thickness of the adhesive layer being determined by a conventional doctor blade or in other suitable manner. The upper roller 30 is maintained at a predetermined distance from the lower roller 29 so that the mat 28 is kept in constant contact with the lower roller. This assures an even and uniform transfer of the adhesive to the mat. Immediately after the adhesive is applied, the mat is placed against the back surface of the tiles assembled in the mounting board as is illustrated in Figure 7. This must be done carefully to prevent misalignment of individual tiles. After the backing sheet, coated with adhesive, has been positioned on the back surface of the tiles, it is pressed firmly into contact with the tiles for a sufficient time to allow an initial bond between the mesh and tiles to be developed. The period and magnitude of pressure should be sufficient to overcome the stiffness of the fiber mesh and force the strands into intimate contact with the individual tiles as well as to allow the adhesive to wet the tile surfaces and develop sufficient tackiness to remain in a fixed position during the remaining steps of the process. We have discovered that when a mesh of the stiffness required to handle the weight of the sheet is used with an adhesive of the preferred composition, a pressure-time cycle of .6 pound per square inch for 15 seconds will produce an initial bond sufficient to hold the tiles and mesh in close contact when the pressure is released for the subsequent processing.

The pressure should be applied evenly and with a minimum movement of the tile to prevent misalignment of individual pieces. This can be accomplished if the pressure is applied with compressed air, hydraulic or mechanical means or by gravity weight rather than by force of hand. The pressure is transmitted to the total area of the mat 28 by means of a steel plate 31 of sufficient area covered with a yieldable cushion 32;

of material such as sponge rubber. Because of the tackiness of the adhesive, it is preferable to cover the surface of the sponge rubber with a non-wettable substance 33, such as a thin membrane of fluorocarbon such as "Teflon." The sponge rubber surface cushion on the pressure plate suitably forces the mesh into contact with the tiles despite any differences in thickness between them or unevenness in the strands. The press may be incorporated into the process in a variety of different ways depending upon convenience and economy of the labor operations involved. It may be arranged in such a manner that pressure is applied to the sheet while it is still resting on the easel.

On completion of the pressing cycle, the mounting board containing the tile assembly to which the adhesive-coated mesh has adhered is transferred to a conveying mechanism 34 consisting of a continuous chain or belt. The assembly is moved at a predetermined rate of speed through a chamber 35 in which heated air at relatively high velocity is blown against the tile surface to which the mesh is adhered. This removes remaining volatile solvent or vehicle from the adhesive, thereby developing its maximum adhesion. When water-based or emulsion type adhesives are used, drying is mandatory to prevent softening or re-emulsification of the adhesive during the cooling cycle when high humidity is present. Heating also cures thermo-setting ingredients or additives which have been incorporated into the adhesive or mesh sizing in order to produce desired characteristics in the finished products, such as water resistance.

It has been found possible to greatly speed up the drying and curing of the mesh and adhesive by subjecting the exposed surface of the sheet to a blast of hot air in such a manner as to promote maximum surface heating and drying without heating the full weight of the entire tile. A typical heating cycle which produces satisfactory results is to subject the sheet to a blast of air at 400° F. with a volume of approximately 7000 cubic feet per minute for a period of two minutes while the sheet is conveyed continuously through the heating chamber. During a cycle such as this the temperature of the adhesive and mesh will reach 260° F. for a period of approximately 1½ minutes.

At the completion of the drying and curing cycle, the thermoplastic properties of the adhesive render the bond between the mesh and tile too soft to remove the sheet from the mounting board without serious distortion of the sheet and misalignment of the individual tiles. However, by conveying the assembly into a cooling chamber 36, insulated from the heating chamber 35, and subjecting the exposed surface of the sheet to a blast of cool air, it is possible to render the adhesive sufficiently stiff or rigid to enable the sheet to be lifted from the mounting board and transferred directly to packing cartons without distortion of the sheet or misalignment of individual tiles. With the preferred adhesive, for example, it has been found that it is desirable to cool the exposed surface of the sheet to approximately 130° F. or below before the assembly may be properly handled. A typical cycle for accomplishing this is to use air at a volume of 6850 cubic feet per minute and temperature not exceeding 115° F. for a period of four minutes.

At the completion of the cooling cycle, the tiling sections emerge from the cooling chamber, still transported by the conveyor. At this point an operator removes the assembled sections from the mounting board, and inspects the assemblies for proper tile alignment. The sheets are then completed and ready to be packed. They are dimensionally stable during storage awaiting use, as well as when they come in contact with water at the time of installation.

The product of the process disclosed in Figures 5 through 9 is a sheet of tile partially shown in Figures 10 and 11. As illustrated, individual tiles 23 are secured to the mat 28 woven of paper strands 29 in an over and

under mesh, with Leno strands 40 interspersed. The strands are flattened to oval shape to provide a greater area of contact with the tile surface. The adhesive also coats the strands 39 securing them to the tile pieces and to one another at points of intersection 41. There may also be adhesive on the backs of the tiles as at window areas 42.

At the point of use the tiling section, constituting the plurality of tiles, is placed over or against the sub-surface to which the tile is to be mounted. Thus, an inorganic or organic bonding medium first is applied in the conventional manner either to the sub-surface or to the back of the tiling section or both according to one or another of the common tile setting techniques, after which the tiles are beaten into place in the usual way. The tiles thereby become bonded to the sub-surface, after which grout is applied to the spaces between the tiles to complete the installation.

When ceramic tile is bonded to a base, stresses develop because of dimensional changes caused by variations in temperature, humidity, moisture, and by ageing. These changes, unfortunately, are not uniform, for which reason internal shearing and dimensional stresses are set up. If these stresses become sufficiently large, the bond ruptures.

One of the stresses which is particularly severe where inorganic cement such as mortar or neat cement is used for the bonding medium arises through shrinking of the sub-surface wall or floor, e.g., mortar, or the bonding medium applied thereto, or both. As an inorganic cement sets, crystallization occurs through hydration of the cement in hardening. At this time cement is adhered to the back face of the tile but the latter, being inert to moisture, is not subject to shrinkage or expansion, at least of the same order. Thus, the bond is subjected to a high shear stress concentration. The stress is greatest at the peripheries of the tiles and as shrinkage continues with ageing, the stress may, and frequently does, become sufficiently high to overcome the tenacity of the bond, whereupon the tile becomes unfastened.

In accordance with the present invention, some of the cement is adhered to some of the areas of the tile per se, and some of the cement at other areas is adhered to the yieldable adhesive through which the tile is joined to the backing medium or to the adhesive which as windowed across openings of the backing medium. At such places the cement is bonded to a yieldable medium which, in turn, is adhered to the tile. The yieldability of the inter-layer of adhesive accommodates at least some of the differential expansion and thereby maintains security of bonding.

Where a twisted paper or irregular strand backing is used in fabrication of the tiling sections, a second advantageous result is provided. Through the relative thickness and oval or irregular configuration in cross-section of the strands of which the backing material is constituted, recesses are provided at the nip areas where the inner faces of the strands are adhered to the back sides of the tile. Bonding medium entering these areas, whether of the organic or inorganic type, forms a mechanical interlock with the strands and the tile adhered thereto. Security of bonding also is accomplished by sub-division or spacing of the areas of the individual pieces of tile to bonding medium. Where differential contraction is exerted over a unit area corresponding to the total area of a piece of tile, it frequently is sufficient to cause bond failure, whereas the unit stress becomes greatly reduced where the bonding area is sub-divided into a plurality of small areas conforming to those spaces between the strands of the backing fabric through which the bonding medium is in engagement with the tile. In other words, the shear stresses developed at each small area of a piece of tile are reduced to the point where bond failure through over-stressing does not occur. It is further to be noted that adhesive is squeezed out between the strands and

the tile at some areas of the backing. In view of the yieldable nature of the adhesive, the adhesive at such areas can absorb relatively large deformation and thereby survive high shear stress. Where the strands of the backing themselves also are of an appreciable thickness, as disclosed, which is desirable but not absolutely requisite to the practice of the invention, the strands produce a network of crossing grooves in the layer of bonding medium. Along the grooves the bonding medium itself is weakened laterally to such extent that cracks will occur in the bonding medium along the lines of weakening before bond rupture will occur.

Where tiling sections are to be made in accordance with the present invention, but only for installation in a mastic or other type bonding medium which is substantially free from water, treatment of the backing sheet to render it dimensionally stable in the presence of water may be omitted. However, where water is present in the bonding medium which is likely to be used by the tile setter, the treatment of the backing sheet to render it dimensionally stable precludes shrinkage of the backing sheet which might otherwise cause cracks to develop along the outer edges of the tiling sections, that is, where one section is arranged adjacent another. For instance, if the backing sheet, when wet, shrinks appreciably more than $\frac{1}{32}$ of an inch in a 2 foot length, then it will be seen that if the sheets of tiling are laid up adjacent one another over a large wall area, the shrinking of the backing in each sheet will result in an over-all contraction of the size of that sheet shortly after installation and, with similar contraction in adjacent sheets, the spaces between the tiles of adjacent sheets will become noticeably greater than the spaces between the individual tiles on the sheets. In such circumstances, the wall will have an undesirable series of cracks visibly corresponding to the sheet sizes.

Thus, this invention provides an improved method of setting tile, an improved resulting structure, an improved sheet of pre-arranged tile, and an improved method of making it.

Having described our invention, we claim:

1. A new article of manufacture consisting of a backing sheet, a plurality of individual tile pieces mounted on said backing sheet with their backs to the backing sheet, said tile pieces arranged in the relative positions in which said tile pieces are to be set, with crevices between the individual tile pieces to provide space for grouting and for the material in which the tile pieces are to be set, said backing sheet being a lattice constituted by strands which cross one another angularly, the size of the openings between the strands of the backing sheet being so related to the back dimensions of said tile pieces that a plurality of openings between the strands of the backing sheet occur within the area bounded by each piece of tile, the said strands being composed of fibrous material, and water resistant elastomer, which is adapted to bond with cement mortar, disposed upon said strands in areas thereof in which the strands are overlaid by the backs of the tile pieces thereby attaching said tile pieces to said backing sheet and also in all areas between points of attachment to different tile pieces to stiffen said strands whereby said strands are relatively flexible transversely to the plane of the backing sheet but are sufficiently axially unyieldable to sustain the weight of the mounted tile pieces under compression and to maintain the selected relative positions of the tile pieces.

2. The new article of manufacture of claim 1 wherein the backing sheet is a rectangle and the strands of the backing sheet are substantially parallel to an edge of said rectangle.

3. The new article of manufacture of claim 1 wherein the strands of the lattice are constituted by twisted kraft paper.

4. The new article of manufacture of claim 3 wherein the strands of twisted kraft paper have a thickness in the plane of the backing sheet which is greater than the

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thickness of the strands in a plane at right angles to the plane of the backing sheet.

5. The new article of manufacture of claim 1 wherein the elastomer is constituted by a major percentage of plasticized polyvinyl acetate and a minor percentage of melamine formaldehyde. 5

6. The new article of manufacture of claim 3 wherein the elastomer is constituted by a major percentage of plasticized polyvinyl acetate and a minor percentage of melamine formaldehyde. 10

7. The new article of manufacture of claim 1 wherein the elastomer is deposited on limited areas of the backs of the tile pieces adjacent to the strands which are bonded to the backs of the tile pieces and wherein other areas of the backs of the tile pieces are exposed, whereby the sheet of mounted tile pieces may be set in cement mortar and be bonded thereto by both rigid bonds and flexible bonds. 15

8. The new article of manufacture of claim 1 wherein the lattice is dimensionally stable in the presence of water. 20

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References Cited in the file of this patent

UNITED STATES PATENTS

712,168	Worth	Oct. 28, 1902
762,428	Munro	June 14, 1904
1,784,008	Herrmann et al.	Dec. 9, 1930
2,027,435	Kallander	June 14, 1936
2,100,958	Honigmann et al.	Nov. 30, 1937
2,112,241	Hyde	Mar. 29, 1938
2,265,614	Schmohl	Dec. 9, 1941
2,274,189	Congleton	Feb. 24, 1942
2,308,650	Desagnat	Jan. 19, 1943
2,448,638	Murray et al.	Sept. 7, 1948
2,474,292	Weidner et al.	June 28, 1949
2,588,543	Kunze et al.	Mar. 11, 1952
2,592,510	Casebolt	Apr. 8, 1952
2,742,391	Warp	Apr. 17, 1956
2,844,955	Talbott	July 29, 1958