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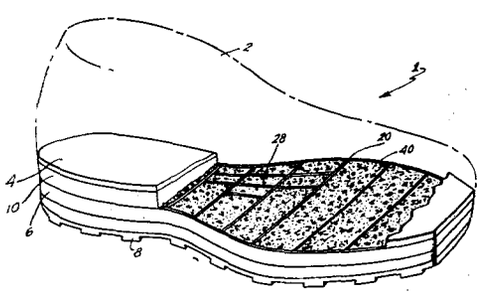
(71) Applicant: **Wolverine World Wide, Inc., 9341 Courtland Drive, N.E., Rockford Michigan49351 (US)**

(72) Inventor: **Hill, Irving David, Unit 34 2250 West Good Hope, Milwaukee Wisconsin 53029 (US)**
Inventor: **Turner, Jerome Allen, 7 Green Heather Court, Baltimore Maryland 21208 (US)**

(74) Representative: **Robinson, Anthony John Metcalf et al, Kilburn & Strode 30 John Street, London, WC1N 2DD (GB)**

(54) Athletic shoe sole and method of manufacture.

(57) An athletic shoe sole and a method of making the same which includes a pre-formed structure (20) having a plurality of dividers (22) that define a plurality of cells (24), the cells having therein an expanded, resilient material (40) such that the resilient material and therefore the sole has a varied hardness, the hardness being greater in zones (42) closer to the dividers than the hardness of zones (44) removed from the dividers. The preformed size and shape of the cells may vary throughout the extent of the sole, resulting in a gradually-varying average hardness. At least part of the compression properties may result from the mechanical properties of the dividers (22) themselves.



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ATHLETIC SHOE SOLE AND METHOD OF MANUFACTURE

The invention relates to an athletic shoe sole and to a method of manufacture thereof.

Various designs and materials have been used in the manufacture of athletic shoes with resilient soles. Both the soles and overall design of such athletic shoes are greatly determined by the particular athletic activity that the user is to engage in while wearing the shoes. Activities which involve a great deal of stopping and starting demand a shoe which differs greatly from one designed for long periods of sustained running, while sports which require a great deal of turning demand a design different again from either of these two.

One factor which is beneficially varied in the design of different shoes is the hardness or cushioning provided by the sole at various points beneath the user's foot. The amount of pressure exerted upon different parts of the sole varies beneath a stationary foot, but varies even more dramatically during the course of a user's stride. Different amounts of support must be provided to the different portions of the foot in order to maintain the greatest degree of athletic effectiveness of the shoe and the correct posture of the wearer. As an example, a runner generally first strikes the outer valgus side of the heel against the ground while striding, with a tendency to impart a jolt to the heel of the runner. For this reason it may be desirable to have a softer, cushioning area located at that portion of the sole heel. However, as the runner completes his stride, many people tend to roll

inward on their heel, and therefore it may be preferable to include a stiffer supporting portion along the varus portion of the sole.

In some shoes different materials having varying degrees of hardness have been dispersed throughout the sole in attempts to effect such beneficial changes in hardness of athletic shoe soles. These may take the form of material inserts into the sole, or may include various additional layers of material located at various points. Such shoe sole constructions require additional manufacturing steps and apparatus, which increases the cost of such manufacturing. It is desirable to produce such changes in sole hardness without a series of complex or lengthy procedures.

According to one aspect of the present invention, an athletic shoe sole is characterised by a pre-formed structure having a plurality of dividers defining a plurality of cells, the cells having therein a resilient material having a hardness greater in a region near a divider than in a region removed from a divider.

According to a second aspect of the present invention, a method of manufacturing a sole comprises the steps of: providing a configured sole mould; positioning in the mould the pre-formed structure; introducing the resilient material into the mould and into the cells, the resilient material contacting the dividers; causing the resilient material to arc to result in said sole.

According to a third aspect of the present invention

a method of forming an athletic shoe sole having regions of differing average hardness over its extent to accommodate physiological requirements, comprises the steps of: arranging a plurality of dividers in a pattern defining a plurality of cells; introducing into the cells flowable resilient material; causing first portions of the material to contact the dividers and second portions to remain spaced from the dividers, and curing the material such that the first cured portions have a hardness greater than the second cured portions.

According to a fourth aspect of the present invention a method of forming an athletic shoe sole comprises: providing a sole mould; positioning in the mould a pre-formed structure having a plurality of dividers defining cells; introducing a resilient material into the mould and into the cells, the resilient material contacting the dividers; causing the resilient material to cure to result in a sole having a hardness greater in regions closer to the dividers than in regions removed from the dividers.

The invention may be carried into practice in various ways, and several specific embodiments will now be described by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of a pre-formed structure, prior to being filled with the resilient material;

Figure 2 is a perspective, fragmentary view of an athletic shoe sole unit showing the shoe upper in phantom;

Figure 3 is a side elevational, sectional view of a mould having a preformed structure located therein prior to the introduction of resilient material;

Figure 4 is a side elevational, sectional view of a sole unit;

Figure 5 is a side elevational, sectional view of another sole unit;

Figure 6 is a side elevational, sectional view of another sole unit;

Figure 7 is a side elevational, sectional view of another sole unit; and

Figure 8 is a side elevational, sectional view of another sole unit.

In one embodiment of the present invention, shown in Figure 2, an athletic shoe 1 includes a shoe upper 2 which is joined to an insole 4, a midsole 6 and an outsole 8. If desired, the shoe 1 can also include a wedge 10 located between the midsole 6 and the outsole 8, or between the insole 4 and the midsole 6.

The midsole 6 contains a pre-formed structure 20 therein, shown in Figure 1. This structure 20 is made up of numerous dividers or walls 22 which can be moulded as a single unit if so desired. The dividers 22 define a plurality of cells 24 which can have a variety of configurations that are determined by the orientation and location of the dividers 22 to achieve hardness patterns suitable to accommodate specific physiological requirements. As shown in Figure 1, the pre-formed structure 20 has an external edge 26 which

forms an upstanding peripheral wall. A number of cross piece dividers 22 join the edge 26 and each other to form a lattice of cells 24. It is preferred that the cells 24 are not closed cells which have the dividers 22 completely surrounding them, but rather that the cells 24 have at least one open side so as to be accessible to the passage of material thereto.

A blown or expanded resilient material 40 is moulded around the structure 20, thereby filling the cells 24 and coming in contact with the dividers 22. Since the cells 24 are open, the expanded material 40 can be injected into a mould and flow throughout the structure 20. However, in some applications it may be preferred for the surfaces 22 to define closed cells 24 within the structure 20. A closed cell structure would have air chambers completely surrounded by the dividers 22, so that when such a closed cell structure is injection moulded, the closed cells will not be filled, leaving air pockets dispersed throughout the midsole 6. In still other applications it may be preferable only partially to fill some cells 24 with the material 40 by reducing the amount of the material 40 injected into the mould, or by other production means. The resilient material 40 is basically a homogeneous material in composition and density prior to being moulded around the structure 20, except for minor differences which may exist due to the manufacture or handling of the material.

After being moulded around the pre-formed structure 20, however, the resilient material 40 develops a

hardness or density which can vary throughout the midsole 6. Specifically the resilient material in a zone or region such as 42 (see Figure 4) close to structure dividers 22 develops a greater stiffness or hardness than in zone or region such as 44 which is removed from the surfaces 22. Although the complete scientific explanation for this is not fully understood, the result is that regions of the material not close to a surface 22 are softer and provide more cushion to impact. This produces a midsole 6 with a controllably variable degree of hardness or cushioning throughout, determined by the pattern (including number location and orientation) of the dividers, and in which the differing average compression properties arise at least partly from the differing hardness of the resilient material due to differences in cell sizes and shapes.

It is preferred that the pre-formed structure 20 have concentrations of surfaces 22 in certain zones such as 28 (Figures 1 and 2), so that resilient material 40 will have a higher durometer in those zones 28 and thus provide a stiffer support for the user's foot in that location. This concentration of dividers can be produced by either an increase in the number of surfaces 22 in areas of concentration 28, or by the configuration of the dividers 22 provided in such areas 28. Various embodiments of the preformed structure 20 are depicted in Figures 2 and 4 to 8, which show changes in both the configuration and the number of the dividers 22 provided in the midsole 6. Figure 3

indicates a concentrated zone 28 adjacent a zone of lesser concentration. The concentrated zone 28 is created by both an increased number of dividers 22 and by a criss-crossed lattice configuration. As can be seen from the drawings, the surfaces 22 can be vertically oriented, as is shown in Figures 1 and 4; angled, as is shown in Figures 5, 6 and 8; crossed, Figure 7; or any combination of the above, Figures 3 and 5. It is not necessary that dividers 22 extend all the way from one side of the structure 20 to the other side, or all the way from the top to the bottom of the structure 20. The dividers 22 may only extend part of the way between the sides or top and bottom of the structure 20. The dividers 22 may also have interrupted surfaces, such as a sieve-like surface, bars or interwoven strips or filaments.

The pre-formed structure 20 can be manufactured from a variety of materials formed into a self-sustaining configuration. Examples of suitable materials are graphite, boron or other composite fibres, such as the fibre marketed under the trademark "Kevlar" by E.I. du Pont de Nemours & Co., combined into sheets and then laminated into configured structures by known techniques. The structure 20 can also be made from a polymer or other plastic or rubber material which is injection moulded or otherwise formed into a desired structure by known techniques. The important property of the material in the structure 20 is the resulting varying hardness characteristics described in the footwear combination.

The resilient material 40 is preferably a polymer material, such as polyurethane, polyethyl vinyl

alcohol or other similar expandable, resilient material which can be injection moulded to produce an expanded or blown, porous product providing a cushioning layer. Although the applicants do not have a complete scientific explanation of what occurs during such a process of injecting an expandable material around the preformed structure, it is believed that the resilient material 40, upon contacting a divider 22, solidifies quickly, probably developing a skin in that area, thereby locally decreasing the amount of expansion and increasing the density and hardness of the material. The structure 20 may also conduct heat away from material contacting it, to cause the resilient material 40 to harden more quickly in zones near the surfaces 20 to cause an increased final hardness. However there may be some chemical reaction and/or other physical actions.

In one method of making a sole as described above, or a shoe which includes the same, a pre-formed structure 20 is provided which has been manufactured to have the desired configuration and location of dividers. The pre-formed structure 20 is positioned in a mould 50, shown in Figure 3, such as is conventionally used in injection moulding. The pre-formed structure 20 is oriented to allow flow of the resilient material 40 around the structure 20 and into the cells 24. The mould 50 will typically have a top half 52 and a bottom half 54 which define a cavity 56 of the desired configuration. After placing the structure 20 in the cavity 56, the resilient material 40 is introduced into the mould 50, through an injection port 58, so that the material 40 enters the cells

24, contacts the dividers 22, and flows into other portions of the cells. The foamed or blown material 40 is allowed to cure, producing a midsole 6 having a hardness which varies in the desired manner. If the entire sole is moulded as a unitary piece by the above method, it is only necessary to join the sole to an upper 2. If the entire sole is not so moulded as a unitary piece but rather as a separate midsole having the structure 20 therein, the midsole 6 is then joined with the insole 4, the outsole 8 and the wedge 10, Figure 2.

The expert will appreciate that in order to design a sole of the present invention having characteristics adapted to a particular use, the hardness of the sole can be increased in specified zones by changing the configuration of the pre-formed structure 20. An increased concentration of surfaces in those zones or the inclusion of surfaces only in those zones allows the sole to be modelled as desired. Since the pre-formed structure can be made from a single material and moulded in the desired shape, production is fast and efficient. The resilient material 40 is a homogeneous material which is easily injected throughout the sole. This process avoids multiple cutting and insertion steps for placing materials of different hardness in the sole and provides a fast and efficient method of manufacture. If desired, the external edge 26 can provide the outer side surfaces of the midsole 6 to cover and protect the blown material 40, allowing external patterns to be placed on the sole during the initial structure-forming step.

The present invention permits a very gradual change in the hardness of a sole. In contrast, prior techniques to produce shoes which vary the sole hardness by inclusion of different materials having varying hardness would require a large number of inserts of only slightly varied durometer to try to replicate a smooth transition from a soft area to one having a higher durometer. Actually, even with a large number of slightly varied inserts, a sole making use of such to effect a hardness change would produce a step-like or staged hardness increase.

The hardness of the sole can also be altered by a combination of the above-described moulding process and selection of pre-formed structure material. The material stiffness, the orientation, and the material thickness have an effect on compression strength thereof. For example, if the structure 20 is made from a relatively hard or stiff material, hardness can be imparted to the sole by a combination of both the hardened material 42 and the stiffness of the surfaces 22. If the surfaces 22 are desired to provide the dual function of imparting stiffness to the sole and inducing hardness in resilient material 40, the orientation of the surfaces 22 can thus be varied to achieve the end result desired. For example, angled walls 34, such as those shown in Figure 8, may prevent compression in a direction parallel to the walls 34 while allowing compression in a direction perpendicular thereto. The sole may therefore be formed with an isotropic compression properties: this may be so whether or not part of the stiffness is attributable to the dividers

themselves. Thus, the present invention allows for the inclusion of compression-resisting fibres without requiring multiple insertions of separate elements. If desired, the majority or even the entirety of the sole's increased hardness can be imparted by the structure 20.

It will be seen from the preceding that the invention contemplates at least three controlled variables which can be employed and/or varied singly, in duo, or in trio to obtain the desired functional aspects of the shoe. These three are the material of the dividers 22, the design, orientation and number of the dividers 22, and the resilient material 40 in type and/or composition and character, e.g. durometer or the like.

By this invention, therefore, highly sophisticated and specialized athletic shoe support can be achieved in fabrication. These can meet physiological requirements determined by analysis and effected by appropriate placement and orientation of the dividers prior to injection moulding.

CLAIMS

1. An athletic shoe sole characterised by a pre-formed structure (20) having a plurality of dividers (22) defining a plurality of cells (24), the cells having therein a resilient material (40) having a hardness greater in a region (42) near a divider than in a region (44) removed from a divider.

2. A sole as claimed in Claim 1 having differing average compression properties over its extent to accommodate physiological requirements.

3. A sole as claimed in Claim 2 in which the differing average compression properties arise at least partly from the differing hardnesses of the resilient material (40) due to differences in cell (24) sizes and shapes.

4. A sole as claimed in Claim 3 in which the differing compression properties also arise from the mechanical properties of the dividers (22).

5. A sole as claimed in any of Claims 1 to 4 in which the compression properties are not isotropic.

6. A sole as claimed in any preceding claim in which the pre-formed structure (20) has a region of substantially vertical and a region of angled dividers.

7. A sole as claimed in any preceding claim in which the resilient material (40) is an expanded polymeric material.

8. A sole as claimed in any preceding claim in which the resilient material (40) has a gradual transition of hardness from the region (42) near a divider to the region (44) removed from a divider.

9. A method of forming the sole as claimed in any preceding claim comprising the steps of: providing a configured sole mould (50); positioning in the mould the pre-formed structure (20); introducing the resilient material (40) into the mould (50) and into the cells (24), the resilient material (40) contacting the dividers (22); causing the resilient material to cure to result in said sole.

10. A method as claimed in Claim 9 in which said sole is a midsole (6); in combination with the steps of joining the sole to an outsole (8) and to a shoe upper (2).

11. A method of forming an athletic shoe sole having regions of differing average hardness over its extent to accommodate physiological requirements, comprising the steps of: arranging a plurality of dividers (22) in a pattern defining a plurality of cells (24); introducing into the cells (24) flowable resilient material (40); causing first portions of the material (40) to contact the dividers (22) and second portions to remain spaced from the dividers (22), and curing the material such that the first cured portions have a hardness greater than the second cured portions.

12. A process of forming an athletic shoe sole, comprising: providing a sole mould (50); positioning in the mould a pre-formed structure (20) having a plurality of dividers (22) defining cells (24); introducing a resilient material (40) into the mould and into the cells, the resilient material contacting the dividers; causing the resilient material to cure to result in a sole having a hardness greater in regions (42) closer to the dividers than in regions (44) removed from the dividers.

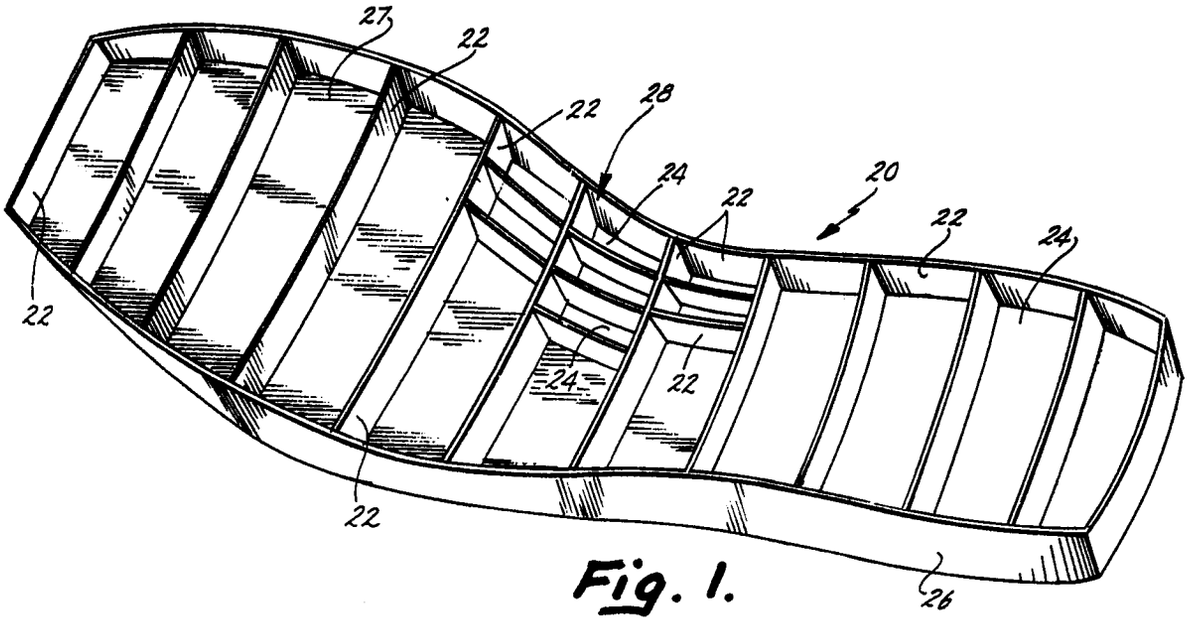

Fig. 1.

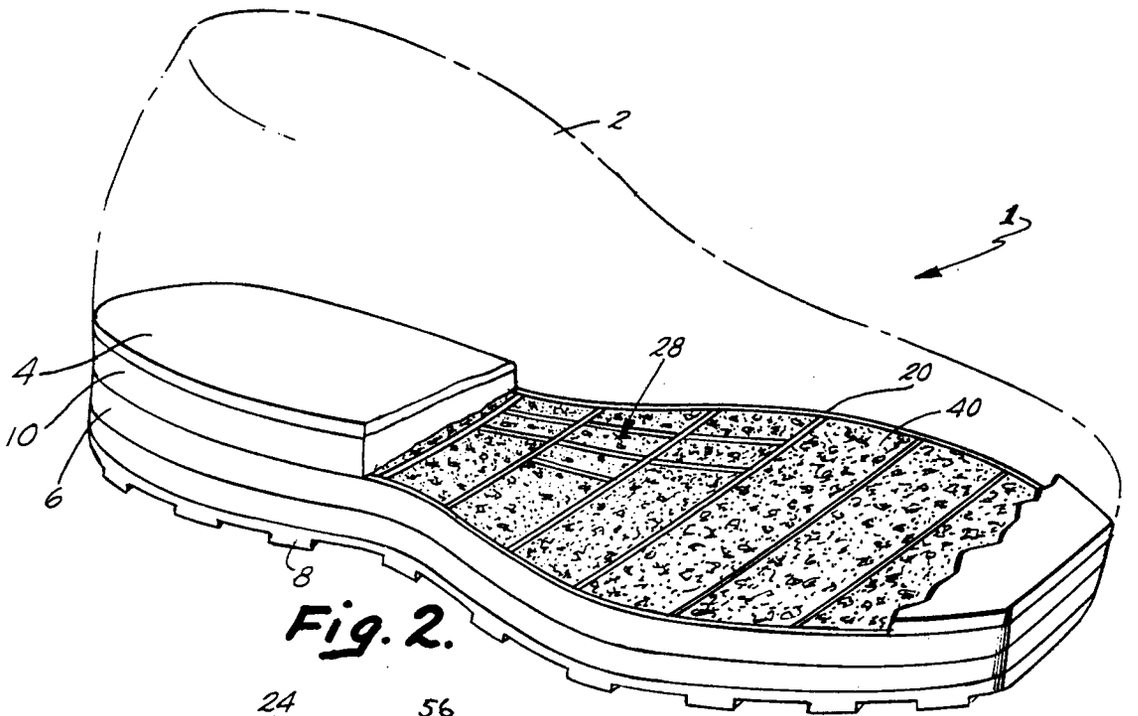

Fig. 2.

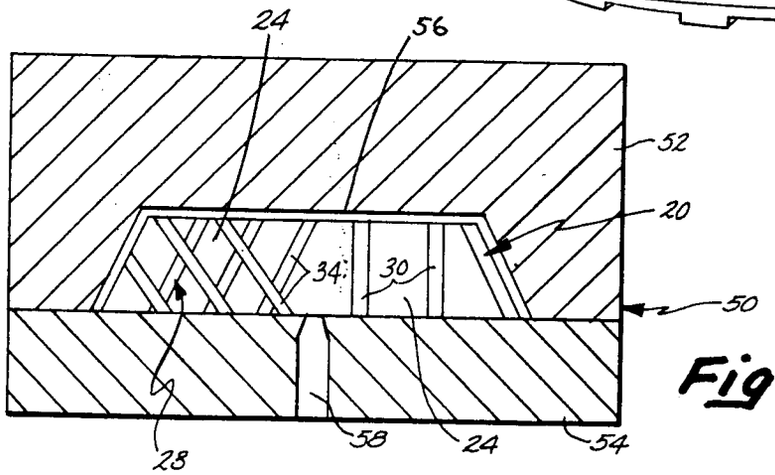

Fig. 3.

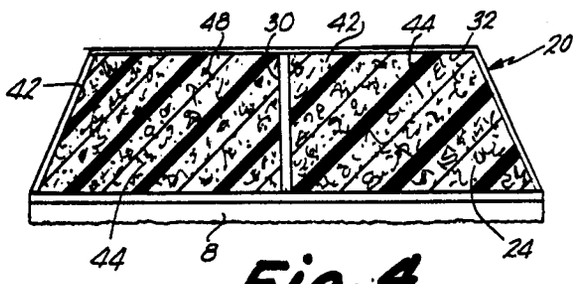

Fig. 4.

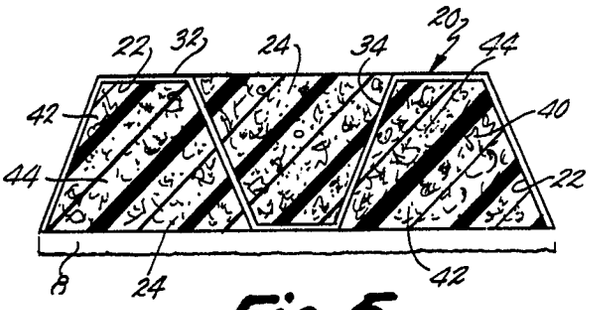

Fig. 5.

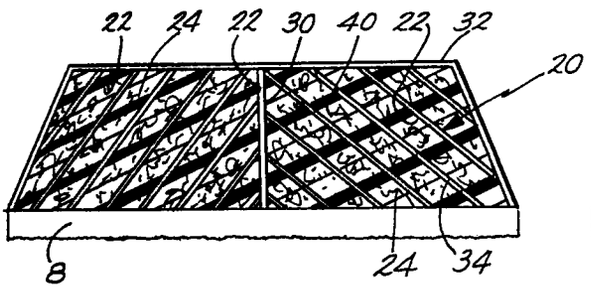

Fig. 6.

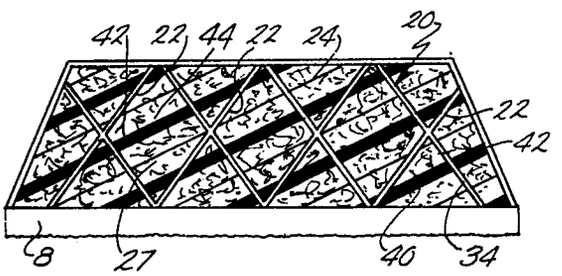

Fig. 7.

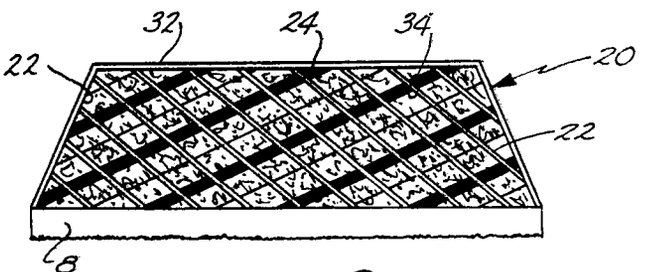

Fig. 8.