PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B26D 1/03, 7/08, B29C 67/00, B29D 31/00 | A1

(11) International Publication Number: **WO 99/04941**

(43) International Publication Date: 4 February 1999 (04.02.99)

(21) International Application Number: PCT/US98/14745

(22) International Filing Date: 23 July 1998 (23.07.98)

(30) Priority Data:
08/899,460 23 July 1997 (23.07.97) US

(71) Applicant *(for all designated States except US)*: FOAMEX L.P. [US/US]; 1000 Columbia Avenue, Linwood, PA 19061 (US).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: DENNEY, Denys [US/US]; 116 Bell Court, Bear, DE 19701 (US).

(74) Agent: ROGOWSKI, Patricia, Smink; Connolly & Hutz, 1220 Market Street, P.O. Box 2207, Wilmington, DE 19899–2207 (US).

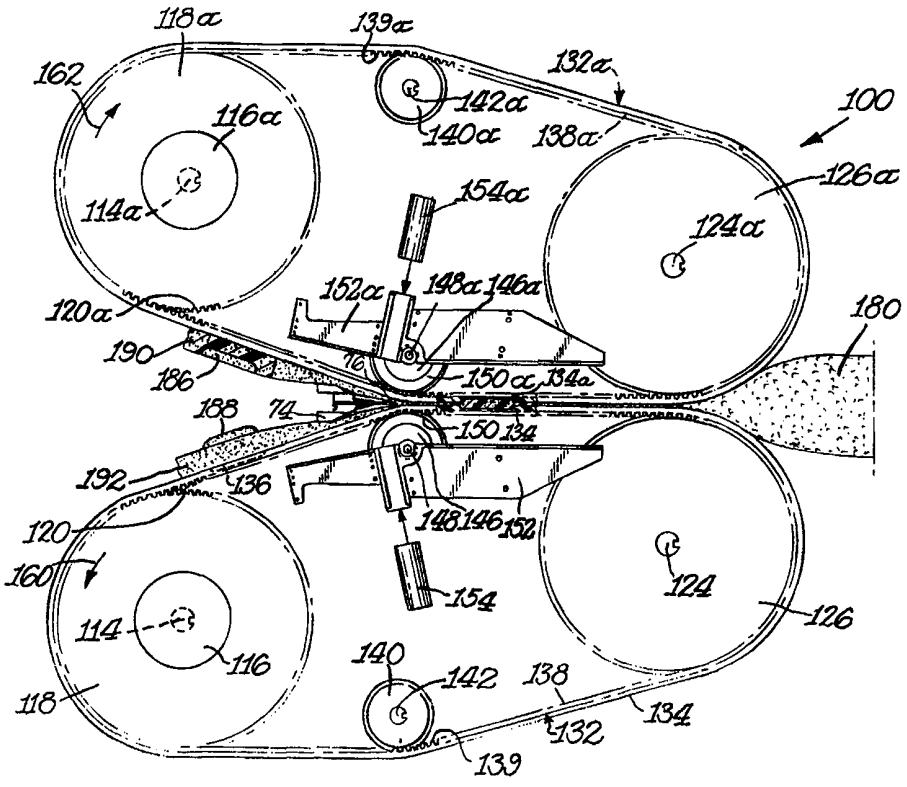
(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: MULTIPLE CONTINUOUS PLATFORM CUTTING METHOD

(57) Abstract

Methods for continuously shaping a compressible or cellular polymer material, such as polyurethane foam, by cutting portions of the material from a surface of one or more slabs of material (180) including (a) compressing one or more slabs of cellular material between a pair of compression rollers (146, 146a) and two moving patterned platforms (132, 132a) interposed between the compression rollers, and (b) transversely cutting the slab or slabs with a blade or blades (76) just as the cellular material emerges from between the compression rollers. At least one of the moving patterned platforms, preferably an endless belt, defines a recess or pattern of recesses. When a slab or slabs of material are fed and compressed between the compression rollers, a portion of the material from one side of the slab or slabs fills the recess or recesses in one of the moving patterned belts. The blade then transversely cuts the cellular material.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	**ES**	Spain	**LS**	Lesotho	**SI**	Slovenia
AM	Armenia	**FI**	Finland	**LT**	Lithuania	**SK**	Slovakia
AT	Austria	**FR**	France	**LU**	Luxembourg	**SN**	Senegal
AU	Australia	**GA**	Gabon	**LV**	Latvia	**SZ**	Swaziland
AZ	Azerbaijan	**GB**	United Kingdom	**MC**	Monaco	**TD**	Chad
BA	Bosnia and Herzegovina	**GE**	Georgia	**MD**	Republic of Moldova	**TG**	Togo
BB	Barbados	**GH**	Ghana	**MG**	Madagascar	**TJ**	Tajikistan
BE	Belgium	**GN**	Guinea	**MK**	The former Yugoslav Republic of Macedonia	**TM**	Turkmenistan
BF	Burkina Faso	**GR**	Greece			**TR**	Turkey
BG	Bulgaria	**HU**	Hungary	**ML**	Mali	**TT**	Trinidad and Tobago
BJ	Benin	**IE**	Ireland	**MN**	Mongolia	**UA**	Ukraine
BR	Brazil	**IL**	Israel	**MR**	Mauritania	**UG**	Uganda
BY	Belarus	**IS**	Iceland	**MW**	Malawi	**US**	United States of America
CA	Canada	**IT**	Italy	**MX**	Mexico	**UZ**	Uzbekistan
CF	Central African Republic	**JP**	Japan	**NE**	Niger	**VN**	Viet Nam
CG	Congo	**KE**	Kenya	**NL**	Netherlands	**YU**	Yugoslavia
CH	Switzerland	**KG**	Kyrgyzstan	**NO**	Norway	**ZW**	Zimbabwe
CI	Côte d'Ivoire	**KP**	Democratic People's Republic of Korea	**NZ**	New Zealand		
CM	Cameroon			**PL**	Poland		
CN	China	**KR**	Republic of Korea	**PT**	Portugal		
CU	Cuba	**KZ**	Kazakstan	**RO**	Romania		
CZ	Czech Republic	**LC**	Saint Lucia	**RU**	Russian Federation		
DE	Germany	**LI**	Liechtenstein	**SD**	Sudan		
DK	Denmark	**LK**	Sri Lanka	**SE**	Sweden		
EE	Estonia	**LR**	Liberia	**SG**	Singapore		

MULTIPLE CONTINUOUS PLATFORM CUTTING METHOD

BACKGROUND OF THE INVENTION

The present invention relates to methods for continuously shaping surfaces of one or multiple slabs of compressible or cellular polymer material, such as polyurethane foam. One or more blades cut portions of the cellular material from the slab or slabs after the slab or slabs have been compressed between compression rollers and a pair of movable patterned platforms.

Several methods and apparatus for cutting slabs of cellular polymer materials have been disclosed in the prior art. For example, U.S. Patent No. 4,700,447 to Spann discloses convolute-cutting slabs of polyurethane foam by compressing a slab or pad of foam between a pair of rolls with opposed spaced projecting fingers arranged in a pattern and cutting the foam with a saw blade transversely just as it emerges from the rolls. The cut slab is then separated into two pads each with convolute-cut surfaces forming a series of peaks separated by valleys. The valleys on one pad are formed by slicing away foam which becomes a mating peak or projection on the other pad. Spann then shaves the peaks to form a more planar top surface. As noted in Spann, convolute cutting alone produces only rounded peaks and rounded valleys, and it is difficult, if not impossible, to produce a cut surface with peaks having substantially flat top surfaces or with recesses having substantially straight side walls. The convolute usually is intended to form the classic symmetrical and repeating "egg crate" pattern of peaks and valleys. To achieve a planar upper surface at other than the recessed portions the tops of the peaks must be cut or shaped in a second step.

Cellular polymer materials may also be cut using a hot wire cutter. A slab of such material is cut by moving the slab relative to one or more hot wires as shown, for example, in U.S. Patent No. 4,683,791 (Demont). Only straight cuts in regular or symmetrical patterns may be formed using a hot wire cutter. See also U.S. Patent No. 4,915,000 (MacFarlane) and U.S. Patent No. 5,573,350 (Stegall).

Shapes may be cut into the surface of a slab of cellular polymer material using a punch cutting apparatus, such as disclosed in U.S. Patent No. 5,299,483 (Ber-Fong). A block of the cellular material is pressed against a template so that a portion of the material is forced through an opening in the template. The exposed material is then cut by a blade and removed, leaving a recess or cavity in the slab. This method cuts one block of material at a time, and only one surface at a time.

U.S. Patent No. 4,351,211 (Azzolini) compresses a block of foam material against a template or die having an aperture therein using a pair of plates with concave and convex portions. The compressed foam is transversely cut along the template as it is held between the plates. More complex cut regions may be obtained than when using a template without the plates with raised and depressed portions, but only one block is cut at a time. Other template or pattern cutting methods are shown in U.S. Patent No. 3,800,650 (Schroder) and U.S. Patent No. 3,653,291 (Babcock).

The surface of a cellular polymer material may be shaped by molding or embossing, as opposed to cutting. U.S. Patent No. 4,383,342 (Forster), for example, discloses injecting the foam-forming composition into a mold cavity. After sufficient curing time, the individual foamed article is removed from the mold. Other one-shot molding techniques and apparatus are known to persons of skill in the art. The molded

cellular polymer product generally forms a tough skin at the surfaces that were in contact with the mold.

Continuous and semi-continuous molding processes are also known. These processes have the same drawbacks associated with one-shot molding techniques. For example, U.S. Patent Nos. 4,128,369 and 4,290,248 (Kemerer, et al.) disclose an apparatus and method for impression molding thermoplastic products. The thermoplastic material in a liquid state is injected between compressed traveling belt molds. As the belt molds travel away from the point of introduction of the thermoplastic, they are cooled, which in turn cools the thermoplastic material, allowing it to solidify. The hardened molded thermoplastic material is removed from between the belts to form the finished product. Kemerer does not show a method for cutting or shaping a compressible and expandable cellular polymer material, such as polyurethane foam.

A method of embossing a foam surface using a patterned metallic embossing belt or band is shown in U.S. Patent 4,740,258 (Breitscheidel). The foam is heated and then pressed against the embossing belt. The belt is removed after the foam surface cools. The embossed surface by design has a hardened skin. No method for cutting or shaping the foam is disclosed.

U.S. Patent No. 5,534,208 (Barr) discloses a continuous rotary method for surface shaping synthetic foams in which the foam is compressed between a compression roller and a die roller having raised and recessed portions. The portions of the foam extruded into the recesses in the die roller are cut away. The compressed foam portions return to an uncompressed state after passing through the rollers. As a result, a mirror-image pattern to the pattern on the surface of the die roller is cut on the surface of the foam.

The diameter of the die roller limits the length of the shaped synthetic foam article that may be formed. In addition, only one foam surface may be shaped with each pass between the die roller and the compression roller.

The prior art does not disclose methods for continuously shaping a compressible or cellular polymer material of unlimited length by cutting to form recesses of various depths and various symmetrical and nonsymmetrical shapes. Nor does the prior art disclose a profile cut product without the hardened skin or hard spots associated with molded or embossed products. Nor does the prior art disclose cutting cellular polymer materials with methods or apparatus that include a movable patterned platform, such as an endless belt or a series of connected panels defining at least one recess or void into which the cellular material may be compressed before cutting the material transversely with a knife blade.

SUMMARY OF THE INVENTION

Methods for continuously shaping a compressible or cellular polymer material, such as polyurethane foam, by cutting and removing portions of the material are disclosed. One or more slabs of cellular polymer material are compressed between a pair of compression rollers which have interposed between them a pair of moving patterned platforms. The slab or slabs of cellular material are held between the patterned platforms and the compression rollers. If one slab is used, portions of cellular material from one face of the slab fill recesses or voids formed in the first moving patterned platform. Portions of cellular material from the other face of the slab fill recesses or voids formed in the second moving patterned platform.

In one embodiment of the method, a single knife blade, positioned between the compression rollers and between the moving patterned platforms and closely adjacent the region in which the slab is compressed by the rollers, cuts the slab transversely just as it emerges from between the compression rollers. After leaving the apparatus, the cut slab is separated into two cut products that have on their cut surfaces pattern cut regions. The cut regions on the first product correspond in mating relation to the raised regions (projections) on the second cut product. Conversely, the cut regions on the second product correspond in mating relation to the raised regions on the second cut product.

The moving patterned platforms may be belts or panels or a series of panels that may be formed into a continuous path. Each of the moving patterned platforms may define several recesses that are separated or interconnected, symmetrical or nonsymmetrical, repeating or nonrepeating. The position of the recesses on one patterned platform need not correspond to the position of the recesses on the second patterned platform. Where the cellular material is compressed so that it fills a recess in one moving patterned platform and there is no corresponding recess in the other moving platform, the knife blade will cut deeper into the slab creating a void in the part of the slab that is farther away from the recess and closest to the patterned platform without the recess. In other words, a greater amount of cellular material is forced to one side of the blade when it fills a recess in the patterned platform. Where the recesses in the patterned platform are complementary to one another, however, such that an equal amount of cellular material is compressed within the recesses of identical depth in both platforms, in this region the slab will be split or cut transversely substantially nearly in the center of its thickness because a nearly equal amount of material is found on either side of the blade.

In a further embodiment, two cut products may be formed from two slabs of cellular material that are cut transversely by a single knife blade. The two slabs in stacked relation are fed between the compression rollers and the movable patterned platforms. The blade is positioned as close as possible to the vertical midpoint between the outer patterned surfaces of the patterned platforms. Where the slabs are compressed between the platforms in regions where neither platform contains a recess, if the blade is centered between the platforms, no portion or no substantial portion of the surfaces of the slabs will be cut by the blade. Similarly, if both of the patterned platforms have recesses of equal depth, no portion or no substantial portion of either slab surface will be forced beyond the cutting edge of the blade.

If, however, a recess is formed in the region compressed between the compression rollers of one platform and there is no corresponding recess formed in the corresponding region of the other platform, then a portion of the cellular material from one of the slabs will be forced beyond the blade edge and the cellular material will be cut such that a recess will be formed in the surface of the slab. The slab adjacent to the platform without the recess will be forced beyond the blade edge and be cut by the blade. Alternatively, if a recess of one depth is formed in the region compressed between the compression rollers of one platform and a corresponding recess of a different depth is formed in the corresponding region of the other platform, cellular material will be cut from the portion of the slab that is forced beyond the blade. The slab adjacent to the recess of greater depth likely will be compressed away from the blade so that the slab adjacent to the recess of lesser depth will be compressed with a portion forced beyond the blade for cutting. The depth of any recesses formed in the surfaces of the slabs will

depend upon the compression factor of the cellular material and on the depth and placement of the recesses in the patterned platforms.

Where two slabs in stacked relation are fed through the compression rollers and between the patterned platforms, each slab is cut to form profile cut surfaces with recesses. Waste material cut from the slabs is removed. Unlike the result when only one slab of foam is cut by the apparatus, the surfaces of the two cut slabs do not nest together.

If it is desired to obtain two cut products with mirror image cut patterns on their surfaces simultaneously, the apparatus may be used with two blades. With this embodiment of the invention, two slabs in stacked relation are fed between the compression rollers and the patterned platforms. The two blades are positioned nearly adjacent to the vertical midpoint between the surfaces of the patterned platforms and near the point at which the slabs emerge from between the rollers. The slab surfaces in contact with each other when the stack is fed between the rollers are the surfaces subject to being cut by the blades. Each blade cuts a portion of the slab surface where the slab material is forced beyond the blade, forming cut portions that correspond in pattern and shape to the pattern and shape of recesses formed in the opposite patterned platform. The depth of cut will vary by the compression factor of the cellular material.

Alternatively, the upper and lower surfaces of a single cellular material slab fed between the compression rollers may be profile cut simultaneously using the apparatus of yet another embodiment of the invention. First and second blades are provided just at the point the compressed cellular material emerges from the compression rollers. The second blade is spaced apart from the first blade, such that the first blade cuts portions of the upper surface of the slab and the second blade cuts portions of the lower surface

of the slab. The cut portions are removed, leaving the finished profile cut product that emerges from between the two blades. With this embodiment of the invention, complex cut profiles may be formed in the upper and lower surface of the slab. The cut portions may be interconnecting or complementary to one another. Portions of the slab in one surface region may be cut simultaneously as portions of the slab in the opposite surface region are cut. Fine patterned shapes not heretofore achieved by continuous cutting methods for cellular materials may be formed using this method.

DESCRIPTION OF THE FIGURES

Numerous other objects, features and advantages of the invention shall become apparent upon reading the following detailed description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic side elevational view of the continuous platform cutting apparatus of the invention having two platforms traveling between two compression rollers and having a single knife blade;

FIG. 2 is a schematic side elevational view of the continuous platform cutting apparatus of FIG. 1, showing how two slabs in stacked relation may be fed between the platforms and cut by the single knife blade;

FIG. 3 is a fragmental side elevational view of an alternate continuous platform cutting apparatus according to the invention having a plurality of compression rollers;

FIG. 4 is a schematic perspective view of a patterned surface of a moving platform for the continuous platform cutting apparatus of the invention;

FIG. 4A is a schematic perspective view of an alternate moving platform for the continuous platform cutting apparatus of the invention;

FIG. 5 is a fragmental side elevational view of an alternate embodiment of the continuous platform cutting apparatus that illustrates profile cutting of a single slab of cellular material with two knife blades;

FIG. 6 is a fragmental side elevational view of the embodiment of the invention shown in FIG. 5 in which the knife blades are positioned in a different orientation;

FIG. 7 is a side elevational view of a cellular polymer underlayment mat defining patterned recesses that have been cut into the mat using the continuous platform cutting apparatus of the invention;

FIG. 8 is a top plan view of the mat of FIG. 7;

FIG. 9 is a fragmental side elevational view of an ornamental star profile cut into a cellular polymer material using the continuous platform cutting apparatus of the invention;

FIG. 10 is a top plan view of the cut material of FIG. 9; and

FIG. 11 is a cross-sectional view in side elevation taken along line 11-11 of FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring first to the embodiment of the invention as shown in FIG. 1, a first drive roller **118** is mounted for rotation on shaft **114**. Shaft **114** is held for free rotation by a supporting frame (not shown). The peripheral edges of the first drive roller **118** are

provided with gear teeth or ribs **120**. Alternatively, separate attached gears may be provided at each end of the drive roller. Shaft **114** is driven by a motor **116**.

First follower roller **126** is mounted for rotation on shaft **124**. Shaft **124** is held by a supporting frame (not shown). Shaft **124** is free to rotate within a bearing recess (not shown).

First endless belt **132** has a patterned facing surface **134** and an opposite surface **138**. The belt **132** is mounted around first drive roller **118** and first follower roller **126**. Ribs or teeth **139** on the opposite belt surface **138** mate with the ribs or teeth **120** provided on the first drive roller **118** and the ribs or teeth **130** on the first follower roller **126**. When the first drive roller **118** rotates on its shaft **114**, it causes belt **132** to travel along a path around the rollers in the direction indicated by arrow **160** in FIG. 1.

First idler roller **140** is mounted for rotation on shaft **142**. Shaft **142** is supported by a frame (not shown).

First compression roller **146** is mounted for rotation on shaft **148**. The shaft **148** is driven by a motor (not shown). The shaft **148** is held within a bearing recess within a supporting frame **152**. Tensioning means **154**, such as springs or air cylinders, urge the shaft **148** and the roller **146** toward a complementary compression surface.

A second drive roller **118a** is mounted for rotation on shaft **114a**. Shaft **114a** is held for free rotation by a supporting frame (not shown). The peripheral edges of the second drive roller **118a** are provided with gear teeth or ribs **120a**. Alternatively, separate attached gears may be provided at each end of the drive roller. Shaft **114a** is driven by a motor **116a**.

Second follower roller **126a** is mounted for rotation on shaft **124a**. Shaft **124a** is held by a supporting frame (not shown). Shaft **124a** is free to rotate within a bearing recess (not shown).

Second endless belt **132a** has a patterned facing surface **134a** and an opposite surface **138a**. The belt **132a** is mounted around second drive roller **118a** and second follower roller **126a**. Ribs or teeth **139a** on the opposite belt surface **138a** mate with the ribs or teeth **120a** provided on the second drive roller **118a** and the ribs or teeth **130a** on the second follower roller **126a**. When the second drive roller **118a** rotates on its shaft **114a**, it causes belt **132a** to travel along a path around the rollers in the direction indicated by arrow **162** in FIG. 1.

Second idler roller **140a** is mounted for rotation on shaft **142a**. The shaft **142a** is supported by a frame (not shown).

Second compression roller **146a** is mounted for rotation on shaft **148a**. The shaft **148a** is driven by a motor (not shown). The shaft **148a** is held within a bearing recess within a supporting frame **152a**. Tensioning means **154a**, such as springs or air cylinders, urge the shaft **148a** and the roller **146a** toward the complementary compression surface of the first compression roller **146**.

The space or gap between the compression surfaces of the first compression roller **146** and second compression roller **146a** is wide enough to allow first and second endless belts **132, 132a** to travel between the rollers.

A portion of a representative patterned facing surface **134** in a belt **132** is shown in perspective view in FIG. 4. The surface includes various shaped recesses **135** and **137**, which may be identical or different shapes with equal or different depths within the

surface **134** of the belt **132**. The recesses may be interconnected or separate and may form a repeating or non-repeating pattern. The recesses in patterned facing surface **134a** may be similar to those formed in the patterned facing surface **134**.

A knife blade **76** is held within casing **74**. The blade **76** must have a sharp tip that is sufficiently sharp to cut cellular polymer materials, such as polyurethane foams. Blade orientation within the casing may be adjusted. Because the blade **76** construction is known and understood by persons of skill in the art of cutting cellular polymer materials, such as polyurethane foams, it will not be described in detail.

The blade **76** is positioned adjacent to the compression rollers **146, 146a** so that the sharp tip of the blade is adjacent to or just beyond the point at which the outer surfaces of the compression rollers **146, 146a** act to their greatest extent to compress material that is placed between the rollers. The blade **76** is also positioned between the patterned facing surfaces **134, 134a** of the endless belts **132, 132a**. The blade **76** should be positioned so that it will not cut the patterned facing surfaces **134, 134a** of the belts **132, 132a**. The blade **76** should not interfere with the rotation of the rollers **146, 146a** or the movement of the belts **132, 132a**.

As a single slab **180** of cellular material, such as polyurethane foam, is fed between the patterned facing surfaces **134, 134a** of the endless patterned belts **132, 132a**, the slab **180** is compressed by the rollers **146, 146a**. When the slab **180** travels into the space between the rollers **146, 146a**, portions of the compressed slab material are held within the recess **136** defined within the facing surface **134** of the belt **132**. The slab **180** travels with the belts **132, 132a** between rollers **146, 146a**.

Knife blade **76** transversely cuts the slab **180** just as the slab **180** emerges from between the compression rollers **146, 146a**. If the knife blade **76** is positioned at the midpoint between the belts **132, 132a**, and if no recesses are present in either patterned belt **132, 132a** surface, the cuts into the slab **180** are made in the very center of the slab thickness, splitting the slab into two parts. When one patterned belt **132** defines a recess **136**, the cellular material of the slab **180** is compressed into that recess, forcing a greater amount of cellular material to one side of the blade **76**. Thus, in the region of the slab in which material has been forced into the recess, the transverse cut into the slab material forms a trough or recess **186** in one cut part surface and a mating projection **188** in the other cut part surface. The depth of the recess **186** formed in the cut part depends upon the depth of the recess **136** formed in the patterned belt **132**. If recesses are formed in both patterned belts **132, 132a** and these recesses are presented simultaneously in the compression region between the compression rollers, the depth of cut in one part and the height of projection in the other part will vary depending upon how much cellular material is compressed to one side or the other side of the blade.

After the slab **180** is cut as it emerges from between the rollers **146, 146a**, the cut slab is separated into two profiled products **190, 192**. The resulting products **190, 192** each have regions with greater and lesser cut portions forming cut profiles in mating relation to each other. The cut profiles will nest together and there is no waste. Slabs of cellular material may thus be provided with profiled surfaces with an endless array of patterns, whether symmetrical or nonsymmetrical, simple or complex, or repeating or nonrepeating.

The blade **76** may be positioned at the midpoint between the patterned facing surfaces **134, 134a** of the endless belts **132, 132a**. Alternatively, it may be positioned closer to one belt than the other. The position and orientation of the blade **76** determines the position of the nominal transverse cut that is made in the slab to divide the slab into two portions. If the blade **76** is held closer to the midpoint, as shown in FIG. 1, the nominal thickness of the two cut portions is nearly equal. A combination of a nominally thicker and nominally thinner cut portion may be formed by moving the blade closer to one of the belts.

Referring next to FIG. 2, in which like reference numerals refer to like parts, an alternate embodiment of the invention **100a** has patterned belts **132, 132a** mounted around follower rollers **126, 126a**, and driven by drive rollers **118, 118a**, respectively. In this embodiment, two slabs of cellular polymer material **180a, 180b** are placed in stacked relation, one atop the other, and fed between the patterned facing surfaces **134, 134a** of the belts **132, 132a**.

In FIG. 2, the knife blade **76** is positioned at the nominal midpoint between the patterned belts **132, 132a** and the compression rollers **150, 150a**. Where the cellular material from the slabs **180a, 180b** is compressed evenly in the region between the compression rollers, no material or only a substantially minor portion of material is cut from either slab. Where a recess or void one of the patterned belts **132** is in the compression region, a portion of the cellular material from the slab **180b** is compressed into the recess, causing a portion of the cellular material from slab **180a** to the opposite side of blade **76** to be then cut by the blade. As the cut slabs emerge from the compression region, the cut portion **184a** may be removed from the slab **180a**, leaving

the resulting recess **186a** in the cut product **190**. The cut recess **186a** corresponds in shape to the recess **135** formed in the patterned belt **132**.

Similarly, where a recess or void formed in the other patterned belt **132a** is in the compression region, a portion of the cellular material from the slab **180a** is compressed into the recess, causing a portion of the cellular material from slab **180b** to the opposite side of blade **76** to be then cut by the blade. As the slabs emerge from the compression region, the cut portion **184** may be removed from the cut product **192**, leaving the resulting recess **186**. The cut recess **186** corresponds in shape to the recess formed in the patterned belt **132a**.

If recesses **135, 135a** are presented to the compression region between the compression rollers simultaneously, the depths of the recesses will determine whether and what amount of the slabs **180a, 180b** will be cut by the blade **76**. If the recesses **135, 135a** are of equal depth and the blade **76** has been positioned at the midpoint between the compression rollers **150, 150a**, then none or only a very minor portion of the cellular material from the slabs **180a, 180b** will be cut. Otherwise, the region with the recess of greatest depth will receive a greater amount of cellular material, causing some material from the more distant slab to pass the knife blade edge and be cut.

The depth of the recesses **135, 135a** of the patterned platforms are typically a small fraction of the depth of the corresponding cuts to be made in the surface of the cellular polymer material **180, 180a, 180b**. Because of the compression factor of the foam against the patterned platforms **132, 132a**, a shallow depression in the patterned platforms **132, 132a** yields a much deeper depression in the foam. For example, a 5/8 inch thick sheet of foam material compressed against a recess **135** of 20 thousands of an

inch in the patterned platform **132**, where there is no corresponding recess **135a** in the other patterned platform **132a**, yielded approximately a 1/2 inch deep depression in the foam slab **180a**. The spacing between the patterned platform surface **134** and the other platform surface **134a**, if all other factors are equal, determines the compression factor of the cellular polymer and consequently the ratio of patterned platform pattern depth to foam cut depth. The depth of cut in the cellular polymer can be reduced for a given patterned platform recess depth by increasing the spacing between the compression rollers and in turn the patterned platforms, thus reducing the compression factor.

Referring now to FIG. 3, wherein like reference numerals refer to like parts, the alternate embodiment of the invention includes additional compression rollers **170, 170a** mounted for rotation in supporting frames **152, 152a**. The additional compression rollers allow the slab or slabs of cellular material to be fed to the compression region more smoothly. The extra rollers reduce slipping between the patterned belts and the cellular material. For purposes of the invention, the "compression region" is the region in which the cellular material is compressed just before it emerges for cutting by the knife blade.

Where the patterned platforms **132, 132a** comprise endless belts as shown in FIGS. 1, 2, 3 and 4, such belts preferably are formed from a flexible material such as rubber or silicone rubber or urethane. Each belt is thick enough to withstand the compressive forces, preferably about 0.375 inches or more, and has a durometer of about 35 or higher. Alternatively, the belt may be formed of fiberglass reinforced polyurethane or other composite materials suitable for endless belts that meet the required thickness and durometer.

As shown in FIG. 4A, rather than using an endless belt, the patterned platform **200** may be constructed as a continuous or endless series of inter-linked panels driven by chain and sprocket. The series of plates **208**, preferably formed from metal or other sturdy substrate, are mounted on shafts **210**. The shafts **210** are held for rotation within bearing sleeves **212**. Y-shaped follower bars **214** are connected at one end to the shafts **210** and at the other two ends to pin members **204** holding together the links **202** of a chain. The chain links **202** are driven by sprockets (not shown), which in turn are driven by motors (not shown).

The plates **208** may define one or more recesses **216**, or portions of recesses **216**. The recesses may be cut through a portion or through the entire thickness of a plate. The recesses may be formed in rectangular, circular or other geometric shape. The recesses may be cut in non-uniform, non-symmetrical and not repeating shapes. The recesses need not be contained wholly within a single plate. Rather, a recess defined by one plate may complement the recess defined by an adjacent plate to form larger or more complex recess shapes.

When a series of plates are used as the patterned platform, the slab of cellular material will be pressed against the plates by a compression roller (not shown in FIG. 4A) so that a portion of the material is compressed into the recesses in the plates and is cut away from the slab by a knife blade just as the cellular material emerges from the compression roller. A support platform **222** is provided below the plates **208** to support the plates when compression forces are exerted on them by the compression roller.

Further alternate embodiments of the invention are shown in FIGS. 5 and 6. In these embodiments, second knife **74a** with blade **76a** is held in spaced apart relation

adjacent to first knife **74** with blade **76**. The blades **76, 76a** are positioned between the compression rollers **146, 146a** and the patterned surfaces **134, 134a** of the platforms **132, 132a**.

Referring first to FIG. 5, the blades **76, 76a** are positioned substantially at the vertical midpoint between the compression rollers. A single slab **180** of cellular polymer (foam) fed between the compression rollers **146, 146a** is cut by both blade **76** and blade **76a** just as it emerges from the rollers. If the region of the patterned platforms between the compression rollers when the slab is compressed has no recesses formed in either platform, the slab will be cut transversely at two places, forming three cut portions **194, 196, 198** without any recesses or projections formed in the cut portions. However, if the region of at least one of the patterned platforms between the compression rollers when the slab is compressed defines a recess, a portion of the slab material is compressed into that recess causing a greater portion of the slab material to be forced to one side of the blades, and cut by the blades. Thus, recesses **195, 197** substantially conforming in shape to the shape of the recesses in the patterned platform are cut into the cut surfaces of the cut products **194, 196**, and projections **199** are formed in the third cut product **198** that emerges from between the blades **76, 76a**. Depending upon the desired end products, and the thickness of the slab of foam **180** and the space provided between the blades **76, 76a**, the cut product **198** also may be discarded as waste.

Referring next to FIG. 6, the blades **76, 76a** are spaced apart to a greater extent and positioned closer to the upper patterned platform **132a**. By adjusting the orientation of the blades, different cut products may be produced from a slab **180**. In FIG. 6, a thin layer **194a** is shaved from the top surface of the slab **180**, a recess **195a** is cut into the cut

product **198a**, and a projection **199a** is formed on the other cut product **196a**. Center cut product **198a** is the usable product, with cut products **194a** and **196a** discarded as waste. However, one, two or all three cut products may form usable products, depending again upon the thickness of the slab of foam **180**, the blade position and spacing, and the desired cut end products to be obtained.

An example of a profile-cut product **300** made according to the invention is shown in FIGS. 7 and 8. The profile cut product **300** represents a cellular polymer insulating barrier or underlayment that will be installed in the interior of a motor vehicle between the floor surface and the carpeting. The upper surface **310** of the underlayment has been cut to provide complex patterns of recesses or voids. As shown in FIG. 8, generally rectangular shaped recesses **312** have been cut into the surface of the product **300**. In addition, more complex shaped recesses, such as interconnecting generally oval shaped recesses **314** and interconnecting straight-edged and curved-edged recesses **316**, may be cut into the cellular material. For the underlayment for a motor vehicle, preferably one surface, here what has been referred to has the upper surface **310**, is cut and the opposite surface remains uncut. The cut surface of the underlayment is placed adjacent to the motor vehicle surface so that the voids and recesses in the underlayment mate with shaped portions projecting from the vehicle surface. In this manner, the underlayment may be provided so as to match the contour of the vehicle interior surface. Once the underlayment is installed in the vehicle, carpet or other covering may be installed adjacent to the uncut and generally smooth surface of the underlayment.

As shown in FIGS. 9-11, a pattern-profiled cut product of cellular material, such as polyurethane foam, may be obtained using the embodiments of the invention as shown

in FIGS. 5 and 6. Thus, portions of material are simultaneously cut away from the top surface and the bottom surface of the slab to result in a complex, three-dimensionally shaped profile cut product. As seen from the top (FIG. 10), the four-pointed star shaped product **300a** has four pointed tip projecting regions and a circular-shaped central divot. As seen in cross section (FIG. 11), material has been cut away from the underside of the pointed tip regions, but these tip regions still have a thickness greater than the thickness of the bordering regions.

The method according to this invention might be used to make profile cut products for a variety of end uses. In addition to motor vehicle carpet systems, profile cut products might be made for other vehicle interior applications, such as headliners, side panels, and dash panels. Profile cut products might also be used for mattresses, mattress pads, pillows, furniture cushions, filters, sports equipment, footwear components and packaging. The above list is intended to be representative and not exhaustive as to all the possible applications for the products of the invention.

While preferred embodiments of the invention have been described and illustrated here, various changes, substitutions and modifications to the described embodiments will become apparent to those of ordinary skill in the art without thereby departing from the scope and spirit of the invention.

WE CLAIM:

1. A method for shaping a slab of cellular polymer material by cutting portions of the material, comprising:

interposing a first patterned platform and a second patterned platform between a pair of compression rollers, wherein said compression rollers each have an outer surface, and wherein said first patterned platform has a facing surface and an outer surface and is position ed with its outer surface adjacent to the outer surface of the first roller and movable with relation thereto, and said first patterned platform defining on its facing surface at least one recess, and wherein said second patterned platform has a facing surface and an outer surface and is positioned with its outer surface adjacent to the outer surface of the second roller and movable with relation thereto;

compressing the slab of cellular polymer material between the first and second patterned platforms and the pair of compression rollers; and

transversely cutting the slab into to mating profiled sections when the slab emerges from between the compression rollers with a blade, said blade positioned so that the first profiled section is formed with a projection in a region corresponding to the region of the slab wherein the first portion of the cellular polymer material is held within the recess of the first patterned platform when the slab is compressed between the compression rollers, and the second profiled section is formed with a recess in a region corresponding to the region of the slab wherein the first portion of the cellular polymer material is held within the recess of the first patterned platform when the slab is compressed between the rollers.

2. The method of claim 1, wherein said second patterned platform defines on its facing surface at least one recess adapted to receive a second portion of the cellular polymer material when a second region of the slab is compressed between the compression rollers, so that after the slab is cut transversely by the blade the first profiled section is formed with a recess in a region corresponding to the region of the slab wherein the second portion of the cellular polymer material is held within the recess of the second patterned platform when the slab is compressed between the compression rollers, and the second profiled section is formed with a projection in the region corresponding to the region of the slab wherein the second portion of the cellular polymer material is held within the recess of the second patterned platform when the slab is compressed between the rollers.

3. The method of claim 2, wherein the first patterned platform is an endless flexible belt.

4. The method of claim 2, wherein the second patterned platform is an endless flexible belt.

5. The method of claim 4, wherein the facing surface of the belt defines a plurality of recesses.

6. The method of claim 5, wherein the facing surface of the belt defines a plurality of recesses in a non-symmetrical, non-repetitive pattern.

7. The method of claim 2, wherein the first and second patterned platforms are formed from a series of panels.

8. The method of claim 7, wherein the panels are metal plates.

9. The method of claim 7, wherein at least one facing surface of at least one panel defines a plurality of recesses.

10. The method of claim 7, wherein the facing surfaces of the panels define a plurality of recesses in a non-symmetrical, non-repetitive pattern.

11. The method of claim 7, wherein the first and second patterned platforms define complementary recesses.

12. A method for simultaneously shaping a pair of slabs of cellular polymer material by cutting portions of the material from surfaces of the slabs, comprising:

interposing a first patterned platform and a second patterned platform between a pair of compression rollers wherein said compression rollers have an outer surface, and wherein said first patterned platform has a facing surface and an outer surface and is positioned between the compression rollers with its outer surface adjacent to the outer surface of the first roller and movable with relation thereto, and said first patterned platform defining on its facing surface at least one recess, and wherein said second patterned platform has a facing surface and an outer surface and is positioned with

its outer surface adjacent to the outer surface of the second roller and movable with relation thereto;

compressing the slabs of cellular polymer material between the first and second patterned platforms and the pair of compression rollers; and

transversely cutting the slabs into two complementary profiled products when the slabs emerge from between the compression rollers with a blade, said blade positioned so that the first profiled product is formed by cutting a recess in the surface of the second slab at a region corresponding to the compressed slab region wherein the portion of the first slab is held within the recess of the first patterned platform when the slabs are compressed between the compression rollers.

13. The method of claim 12, wherein the second platform is a patterned platform having formed in its facing surface at least one recess adapted to receive a portion of the cellular polymer material of the second slab when a second region of the slabs is compressed between the compression rollers.

14. The method of claim 12, wherein the second platform is a patterned platform having formed in its facing surface at least one recess adapted to receive a portion of the cellular polymer material of the second slab when the first region of the slabs is compressed between the compression rollers.

15. The method of claim 12, wherein the blade is positioned near the midpoint of the space between the outer surfaces of the compression rollers.

16. The method of claim 12, wherein the blade is positioned near the midpoint of the space between the facing surfaces of the platforms.

17. The method of claim 12, wherein the slabs have substantially equal thicknesses in an uncompressed state.

18. The method of claim 12, wherein the first patterned platform is an endless flexible belt.

19. The mehtod of claim 12, wherein the second patterned platform is an endless flexible belt.

20. The method of claim 17, wherein the facing surface of the belt defines a plurality of recesses.

21. The method of claim 19, wherein the facing surface of the belt defines a plurality of recesses in a non-symmetrical, non-repetitive pattern.

22. The method of claim 13, wherein the first and second patterned platforms are formed from a series of panels.

23. The method of claim 14, wherein the first and second patterned platforms are formed from a series of panels.

24. The method of claim 22, wherein the panels are metal plates.

25. The method of claim 23, wherein the panels are metal plates.

26. The method of claim 22, wherein at least one facing surface of at least one panel defines a plurality of recesses.

27. The method of claim 23, wherein at least one facing surface of at least one panel defines a plurality of recesses.

28. The method of claim 22, wherein the first and second patterned platforms define complementary recesses.

29. The method of claim 23, wherein the first and second patterned platforms define complementary recesses.

30. A method for shaping two surfaces of a slab of cellular polymer material by cutting portions of the material from the two surfaces of the slab, comprising:

interposing a first patterned platform and a second patterned platform between a pair of compression rollers, wherein said compression rollers each have an outer surface, and wherein said first patterned platform has a facing surface and an outer surface and is positioned with its outer surface adjacent to the outer surface of the first roller and movable with relation thereto, and said first patterned platform defining on its

facing surface at least one recess, and wherein said second patterned platform has a facing surface and an outer surface and is positioned with its outer surface adjacent to the outer surface of the second roller and movable with relation thereto;

compressing the slab of cellular polymer material between the first and second patterned platforms and pair of compression rollers;

transversely cutting the slab of cellular polymer when the slab emerges from between the compression rollers with a first blade, said first blade positioned so that a first profiled surface is formed by cutting a recess in a first surface of the slab at a region corresponding to the compressed slab region wherein the portion of the slab is held within the recess of the first patterned platform when the slab is compressed between the compression rollers; and

transversely cutting the slab of cellular polymer when the slab emerges from between the compression rollers with a second blade, said second blade spaced apart from said first blade and positioned so that a second profiled surface is formed by cutting a recess in a second surface of the slab.

31. The method of claim 30, wherein the second platform is a patterned platform defining on its facing surface at least one recess adapted to receive a portion of the cellular polymer material of the slab when the first region of the slab is compressed between the compression rollers.

32. The method of claim 30, wherein the second platform is a patterned platform defining on its facing surface at least one recess adapted to receive a portion of

the cellular polymer material of the slab when a second region of the slab is compressed between the compression rollers.

33. The method of claim 31, wherein said second blade is spaced apart from said first blade and positioned so that a second profiled surface is formed by cutting a recess in a second surface of the slab at a region corresponding to the first compressed slab region wherein the portion of the slab is held within the recess of the first patterned platform when the slab is compressed between the compression rollers.

34. The method of claim 32, wherein said second blade is spaced apart from said first blade and positioned so that a second profiled surface is formed by cutting a recess in a second surface of the slab at a region corresponding to the second compressed slab region wherein the portion of the slab is held within the recess of the second patterned platform when the slab is compressed between the compression rollers.

35. The method of claim 30, wherein the patterned first platform defines a plurality of recesses.

36. The method of claim 30, wherein the patterned second platform defines a plurality of recesses.

37. The method of claim 30, wherein the patterned first platform is formed from a flexible belt.

38. The method of claim 31, wherein the patterned second platform is formed from a flexible belt.

39. The method of claim 30, wherein the patterned first platform is formed from a series of panels.

40. The method of claim 30, wherein the patterned second platform is formed from a series of panels.

41. A profiled section of cellular polymer material formed according to the method of claim 1.

42. A profiled section of cellular polymer material formed according to the method of claim 2.

43. A profiled product of cellular polymer material formed according to the method of claim 12.

44. A profiled product of cellular polymer material formed according to the method of claim 13.

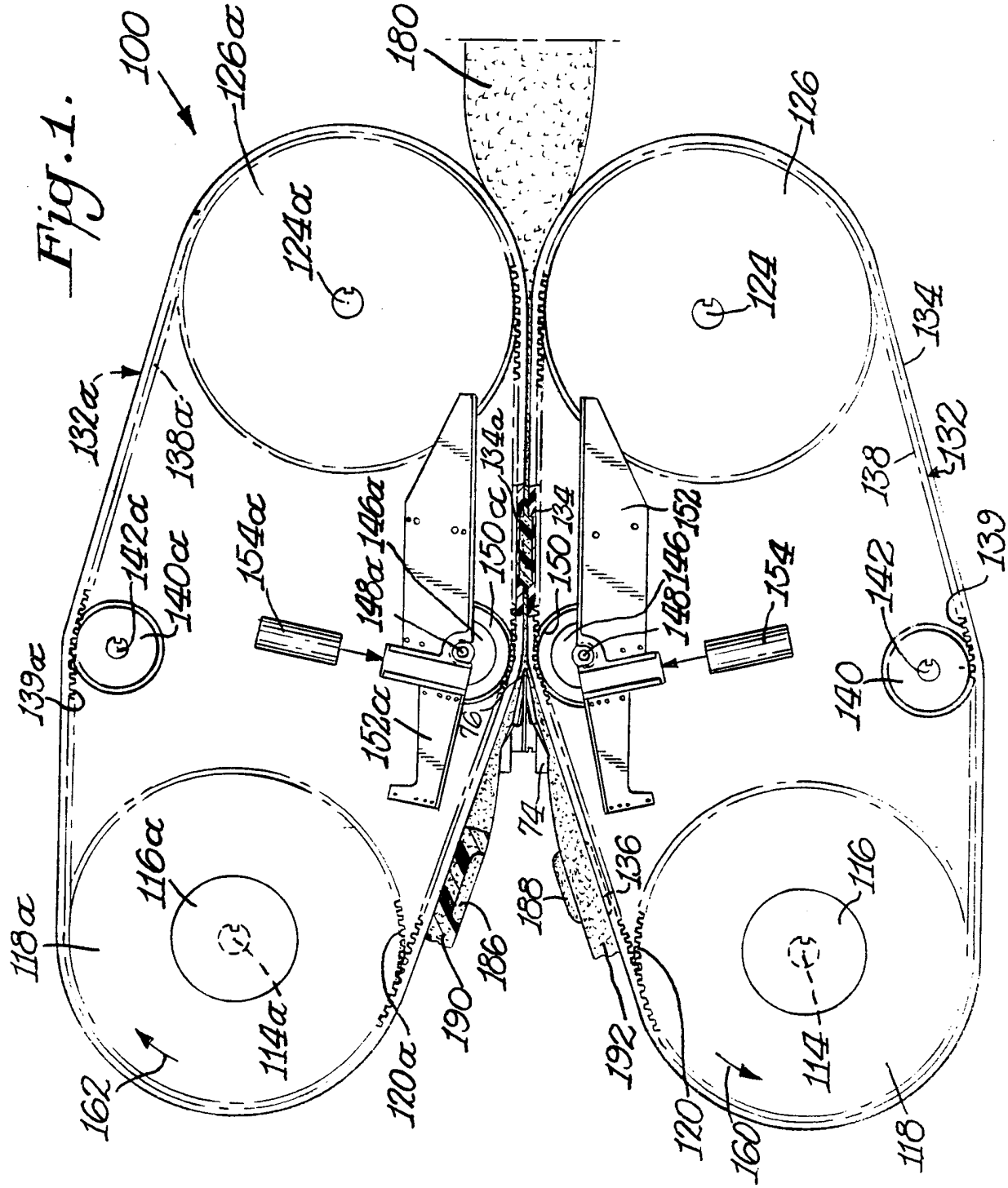
45. A profiled product of cellular polymer material formed according to the method of claim 14.

46. A profiled product of cellular polymer material formed according to the method of claim 30.

47. A profiled product of cellular polymer material formed according to the method of claim 31.

48. A profiled product of cellular polymer material formed according to the method of claim 32.

Fig. 1.


100
126a
180
126
124a
124
134
132a
138a
132
138
139a
142a
140a
154a
148a
146a
150a
134a
150
134
148
146
152
154
142
139
140
152a
76
74
116a
118a
136
188
186
190
192
116
114a
114
120a
120
162
160
118

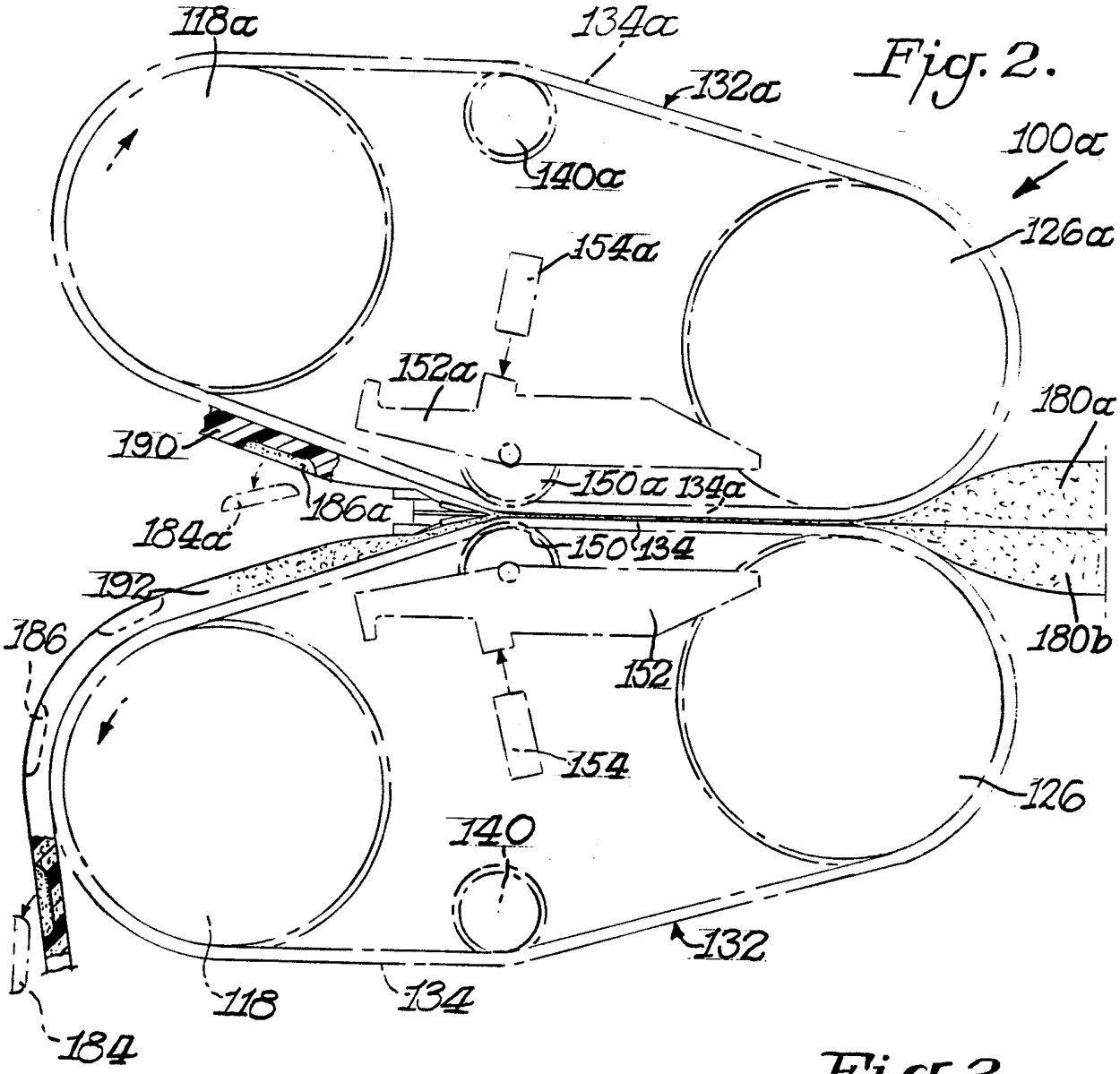

118a
134a
132a
140a
100a
126a
154a
152a
180a
190
150a
134a
186a
184a
150
134
192
186
180b
152
154
126
140
132
118
134
184

Fig. 2.

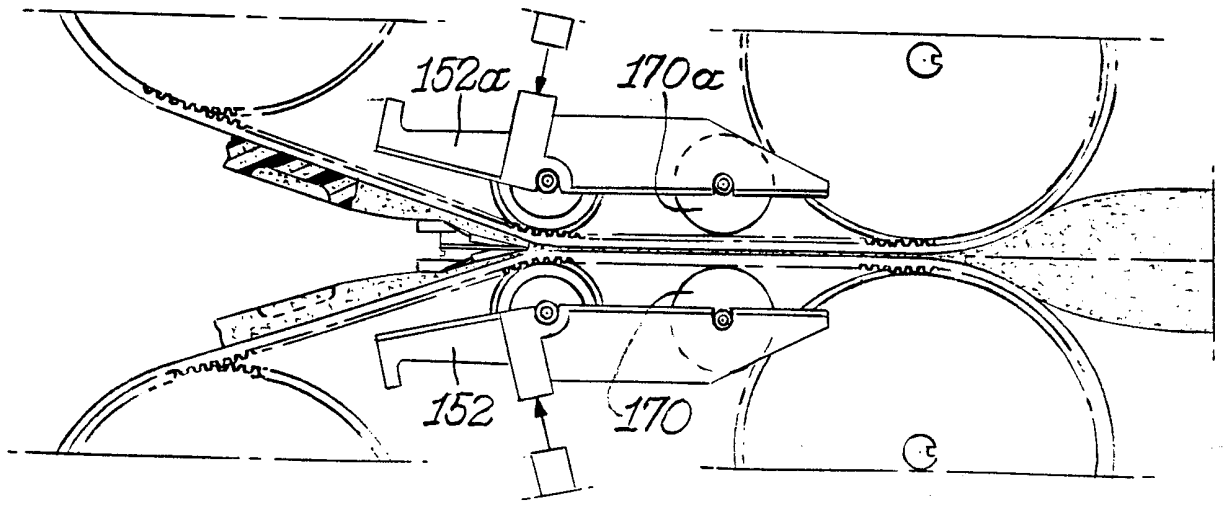

152a
170a
152
170

Fig. 3.

Fig. 4A.

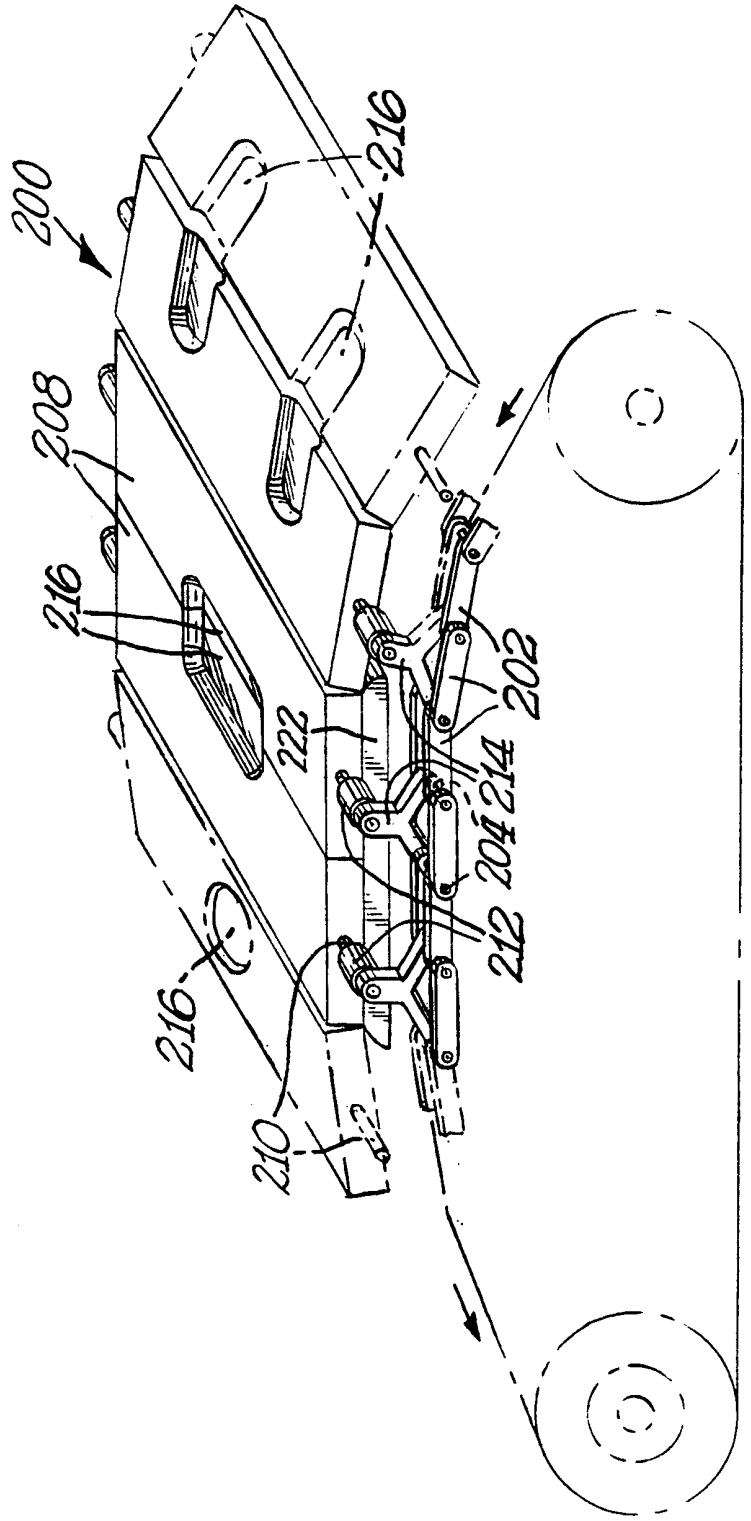


Fig. 4.

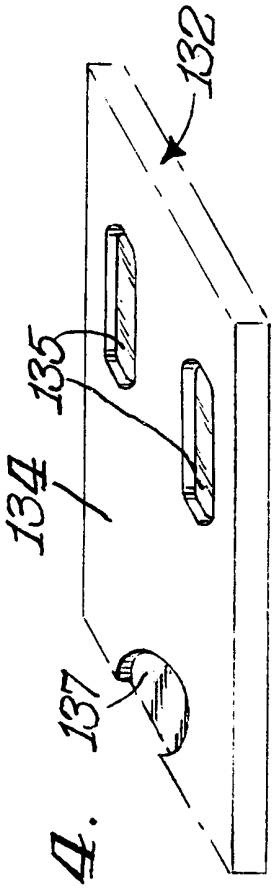


Fig. 5.

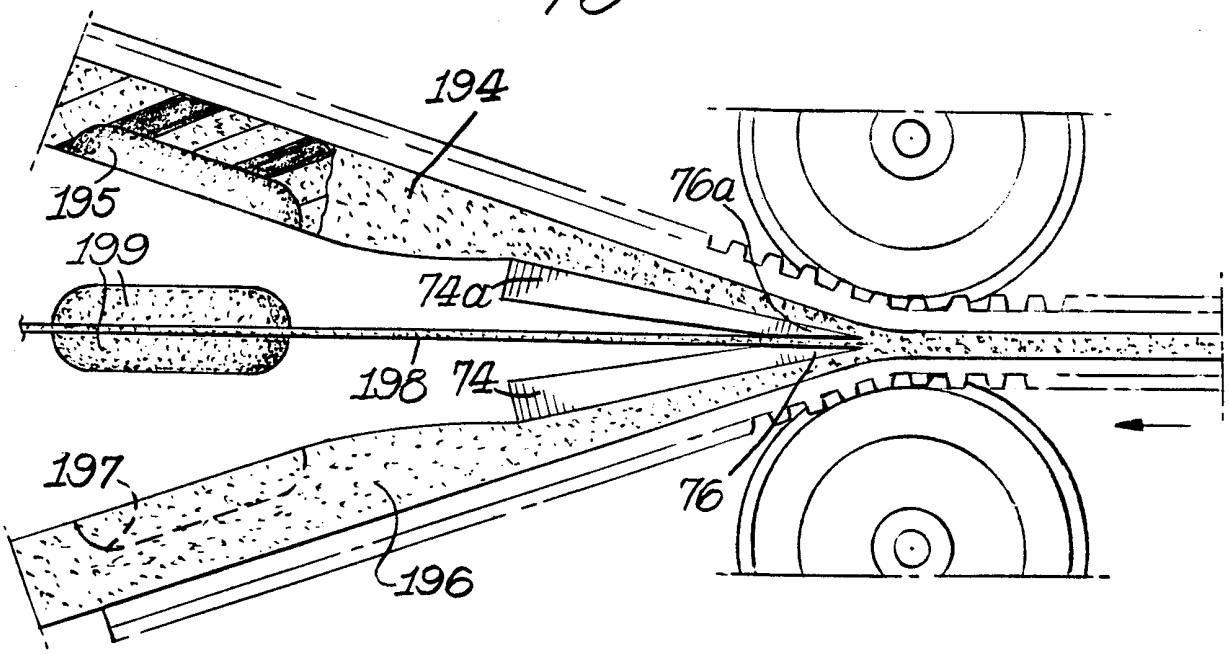

194
195
199
76a
74a
198
74
197
76
196

Fig. 6.

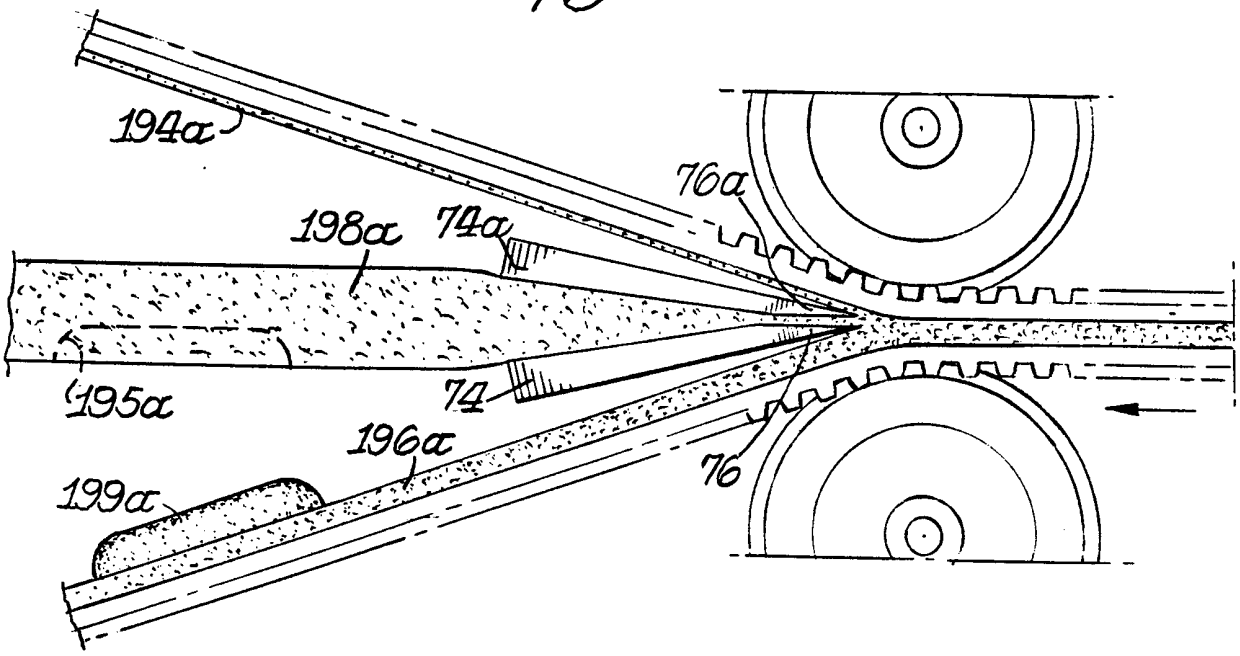

194a
76a
198a
74a
195a
74
196a
76
199a

Fig. 8.

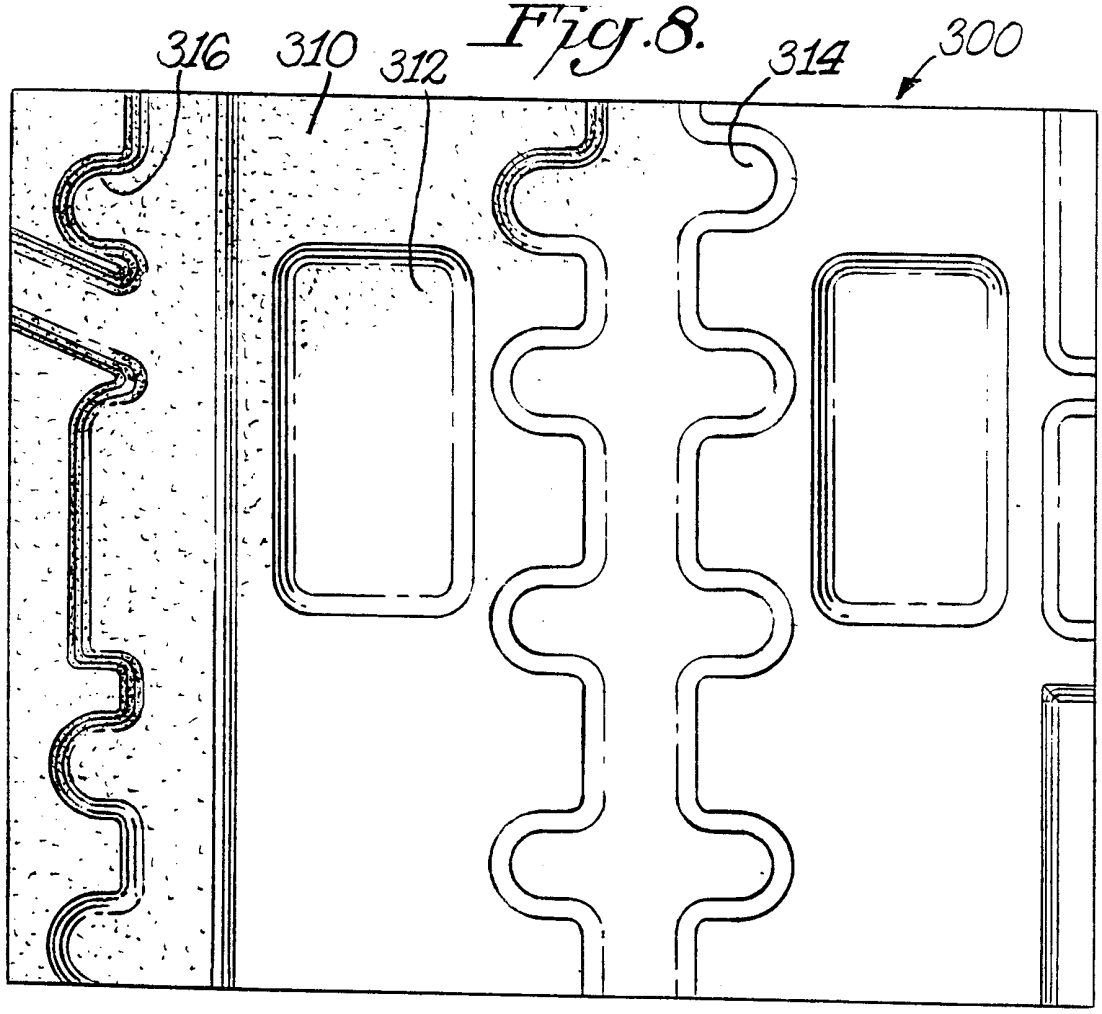


Fig. 7.

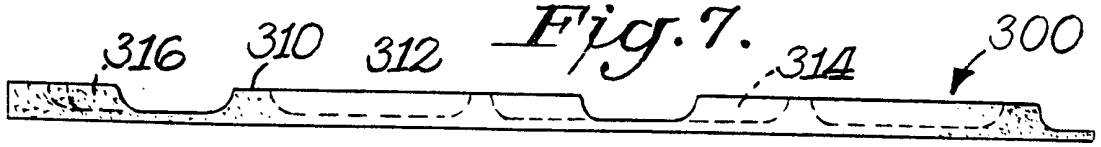


Fig. 10.

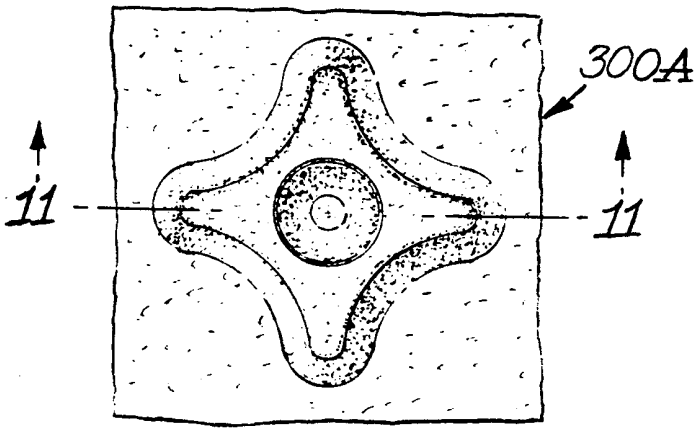


Fig. 11.

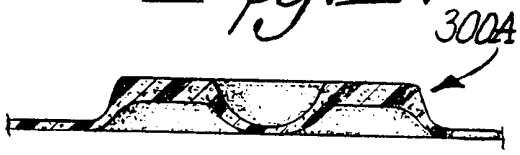


Fig. 9.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/14745

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B26D 1/03, 7/08; B29C 67/00, B29D 31/00
US CL :83/874, 19, 425, 435; 264/160, 163, 293, 321; 425/289, 335, 371

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

None

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

None

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 801,673 A (MOORE) 10 October 1905, see page 2, lines 30-43.	1-32,35-40
---		---
A		33,34
A	US 795,359 A (MOORE) 25 July 1905, see col. 2, lines 1-7.	1-40
A	US 3,186,271 A (KAISER) 01 June 1965, see Fig. 2.	1-40
A	US 3,690,203 A (HUTTEMANN) 12 September 1972, see Fig. 1.	1-40
A	US 3,730,031 A (HUTTEMANN) 01 May 1973.	1-40
A	US 5,477,573 A (BONADDIO et al.) 26 December 1995.	1-40

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 10 SEPTEMBER 1998	Date of mailing of the international search report 13 OCT 1998
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer CLARK F. DEXTER Telephone No. (703) 308-1404 Sheila Veney Paralegal Specialist Technology Center 3700

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/14745

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5,534,208 A (BARR et al.) 09 July 1996.	1-40
A	US 5,688,538 A (BARR et al.) 18 November 1997.	1-40

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US98/14745

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 41-48
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

because these claims are directed to a product, but no structure is set forth to define the product.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

83/870, 871, 874, 19, 176, 424, 425, 425.2, 425.3, 435, 435.2, 856, 858; 264/46.3, 148, 157, 160, 163, 293, 321; 425/289, 335, 362, 371, 373