(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
20 December 2012 (20.12.2012)

WIPO | PCT

(10) International Publication Number
WO 2012/173766 A1

(51) International Patent Classification:
B29C 44/58 (2006.01) *B29C 33/38* (2006.01)
B29C 44/12 (2006.01)

(21) International Application Number:
PCT/US2012/039430

(22) International Filing Date:
24 May 2012 (24.05.2012)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/496,332 13 June 2011 (13.06.2011) US

(71) Applicant *(for all designated States except US)*: **JOHNSON CONTROLS TECHNOLOGY COMPANY** [US/US]; 915 E. 32nd Street, Holland, Michigan 49423 (US).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **FARQUHARSON, Douglas** [US/US]; 836 Cliffs Drive 206D, Ypsilanti, Michigan 48198 (US). **YAMASAKI, Ryoko** [JP/US]; 620 Woodlawn Ave., Ypsilanti, Michigan 48198 (US). **PEIFFER, Eugene** [US/US]; 613 Biltmore Dr., Jefferson City, Missouri 65109 (US).

(74) Agents: **KANTOR, Andrew L.** et al.; P.O. Box 692289, Houston, Texas 77269 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: MOLD CAVITY HAVING GROOVES FORMED BY A FLEXIBLE MESH SHEET

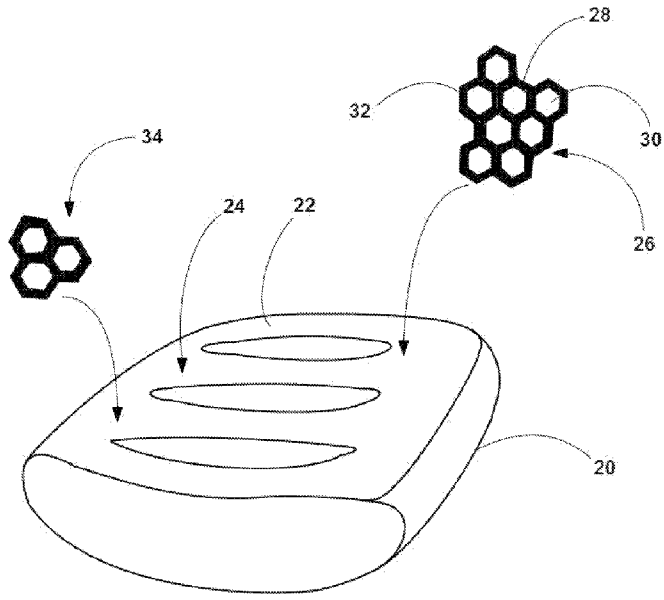


FIG.2

(57) Abstract: A method of manufacturing a mold cavity is provided that includes forming a model (20) having a shape representative of a desired product, and applying a flexible mesh sheet (26) to an exterior surface of the model. The flexible mesh sheet includes multiple ridges (28) forming a repeating cellular pattern. The method also includes forming the mold cavity from the model such that the ridges form corresponding grooves within an interior surface of the mold cavity.

WO 2012/173766 A1

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

MOLD CAVITY HAVING GROOVES FORMED BY A FLEXIBLE MESH SHEET

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority from and the benefit of U.S. Provisional Application Serial No. 61/496,332, entitled "MOLD CAVITY HAVING GROOVES FORMED BY A FLEXIBLE MESH SHEET", filed June 13, 2011, which is hereby incorporated by reference in its entirety.

BACKGROUND

[0002] The invention relates generally to a mold cavity having grooves formed by a flexible mesh sheet.

[0003] Vehicle seating typically includes a seat bottom and a seat back to support a driver or passenger. In certain seating configurations, both the seat bottom and seat back include a rigid chassis, cushions, and a fabric covering. The cushions are coupled to the rigid chassis, and the fabric covering is disposed about the assembly. Certain cushions are formed by injecting a foamable liquid into a mold cavity having a shape corresponding to the desired cushion shape. As the chemicals of the foamable liquid react, the foam expands to fill the interior of the mold cavity, thereby assuming the shape of the cavity. Once the foam hardens, the cushion may be removed from the mold and used within the vehicle seat.

[0004] As will be appreciated, expansion of the foam within the mold cavity displaces the surrounding air. Therefore, to enable the foam to expand, typical mold cavities include vents (e.g., auto vents) having openings sufficiently small to facilitate air passage while blocking the flow of foam out of the mold. Unfortunately, due to the spacing of the vents, air pockets may form between the interior of the mold cavity and the expanding foam. As a result, undesirable voids may be formed along the exterior surface of the cushion. One method to reduce the possibility of void formation is to provide grooves within the interior surface of the mold cavity to facilitate air flow to the vents.

[0005] In certain mold formation techniques, the grooves are directly machined into the interior surface of the mold cavity. Unfortunately, machining the grooves is an expensive and time consuming process, thereby increasing the overhead costs associated with cushion production. In other mold formation techniques, the grooves are formed during the casting process. For example, a model may be constructed (e.g., machined from a block of material) having a shape representative of the desired cushion. Individual linear ridges (e.g., wooden dowels) are then cut and glued to an exterior surface of the model. Finally, the mold cavity is formed from the model such that the ridges form corresponding grooves within the interior surface of the mold cavity.

[0006] Due to the curvature of the model, the linear ridges are divided into short segments, and each segment is meticulously aligned and glued to the exterior surface of the model. As a result, the process of applying the ridges to a model having complex shapes may be exceedingly time consuming, thereby increasing the costs associated with mold production. In addition, an iterative process may be employed to determine an effective location for each ridge. For example, if a mold cavity formed from a model having a particular ridge configuration produces cushions having voids, the ridges may be reconfigured to compensate, thereby further increasing the duration and costs associated with mold production. Furthermore, if fewer ridges are employed to reduce mold construction time, more vents (e.g., auto vents and/or parting line vents) will be utilized to reduce the possibility of void formation. Unfortunately, the additional vents will increase the possibility of expanding foam flowing into the vents, thereby producing flash (i.e., undesirable foam protrusions) on the cushion and/or clogging the vents.

BRIEF DESCRIPTION OF THE INVENTION

[0007] The present invention relates to a method of manufacturing a mold cavity including forming a model having a shape representative of a desired product, and applying a flexible mesh sheet to an exterior surface of the model. The flexible mesh sheet includes multiple ridges forming a repeating cellular pattern. The method also

includes forming the mold cavity from the model such that the ridges form corresponding grooves within an interior surface of the mold cavity.

[0008] The present invention also relates to a mold cavity prepared by a process including forming a model having a shape representative of a desired product, and applying a flexible mesh sheet to an exterior surface of the model. The flexible mesh sheet includes multiple ridges forming a repeating cellular pattern. The process also includes forming the mold cavity from the model such that the ridges form corresponding grooves within an interior surface of the mold cavity.

[0009] The present invention further relates to a product formed by a mold cavity prepared by a process including forming a model having a shape representative of the product, and applying a flexible mesh sheet to an exterior surface of the model. The flexible mesh sheet includes multiple ridges forming a repeating cellular pattern. The process also includes forming the mold cavity from the model such that the ridges form corresponding grooves within an interior surface of the mold cavity.

DRAWINGS

[0010] FIG. 1 is a perspective view of an exemplary vehicle seat that may include a cushion produced in a mold cavity having grooves formed by a flexible mesh sheet.

[0011] FIG. 2 is a perspective view of an exemplary model and an embodiment of a flexible mesh sheet configured to establish grooves in a mold cavity formed from the model.

[0012] FIG. 3 is a top view of an embodiment of a cell that may be employed within the flexible mesh sheet of FIG. 2.

[0013] FIG. 4 is a top view of an embodiment of a mold cavity formed from the model of FIG. 2.

[0014] FIG. 5 is a flow diagram of an exemplary method for manufacturing a mold cavity.

[0015] FIG. 6 is a flow diagram of an exemplary method for applying a flexible mesh sheet to an exterior surface of a model.

[0016] FIG. 7 is a flow diagram of an exemplary method for forming a mold cavity from a model.

DETAILED DESCRIPTION

[0017] FIG. 1 is a perspective view of an exemplary vehicle seat 10 that may include a cushion produced in a mold cavity having grooves formed by a flexible mesh sheet. As illustrated, the seat 10 includes a seat bottom 12 and a seat back 14. In the present embodiment, the seat bottom 12 includes a seat bottom chassis, one or more cushions, and a fabric covering. The seat bottom chassis serves to support the weight of a passenger during normal vehicle operation and during high g-force events (e.g., rapid acceleration or deceleration, etc.). The seat bottom chassis also secures the seat bottom 12 to a floor of a vehicle, and provides a mounting surface for the seat back 14. One or more cushions may be coupled to the seat bottom chassis to provide passenger comfort, and the fabric covering may be disposed about the assembly to provide a desired appearance and/or to protect the internal components of the seat bottom 12. The seat back 14 may be constructed in a similar manner, i.e., from one or more cushions secured to a rigid chassis and wrapped with a fabric covering.

[0018] As illustrated, the seat bottom 12 is secured to a seat track 16. The seat track 16, in turn, is secured to the floor of the vehicle by mounting feet 18. In certain configurations, the seat 10 may be configured to translate along the seat track 16 to adjust a longitudinal position of a driver or passenger. As will be appreciated, adjustment of the seating position may be either manual or assisted. For example, an electric motor may be configured to drive the seat 10 along the track 16 by a suitable mechanism such as a rack and pinion system. In addition, the seat back 14 may be configured to recline with respect to the seat bottom 12. Adjustment of the seat back 14 may also be either manual or assisted by an electric motor, for example.

[0019] The cushions within the seat bottom 12 and/or the seat back 14 may be formed by injecting a foamable liquid (e.g., polyurethane foam) into a mold cavity

having a shape corresponding to the desired cushion shape. As the chemicals of the foamable liquid react, the foam expands to fill the interior of the mold cavity, thereby assuming the shape of the cavity. Once the foam hardens, the cushion may be removed from the mold and used within the vehicle seat 10. As will be appreciated, expansion of the foam within the mold cavity displaces the surrounding air. Therefore, to enable the foam to expand, the mold cavity includes vents (e.g., auto vents) having openings sufficiently small to facilitate air passage while blocking the flow of foam out of the mold. In addition, the mold cavity includes grooves within the interior surface to facilitate air flow to the vents. Consequently, the possibility of developing voids along the exterior surface of the cushion due to the formation of air pockets between the interior of the mold cavity and the expanding foam is substantially reduced or eliminated.

[0020] As discussed in detail below, the grooves within the interior surface of the mold cavity are formed by a flexible mesh sheet. For example, in certain embodiments, the mold cavity is manufactured by a casting process. First, a model having a shape representative of a desired product (e.g., a cushion within the seat bottom 12 or the seat back 14) is formed. Next, a flexible mesh sheet having multiple ridges forming a repeating cellular pattern is applied to an exterior surface of the model. Finally, the mold cavity is formed from the model such that the ridges form corresponding grooves within the interior surface of the mold cavity. In certain embodiments, the mold cavity is formed by applying material (e.g., plaster, a fiber glass/resin mixture, etc.) to the exterior surface of the model to form a pattern, packing sand around the pattern to form an impression, and casting the mold cavity from the impression.

[0021] Because the mesh sheet is flexible, the ridges of the sheet will naturally follow the contours of the model. Consequently, the duration and costs associated with ridge formation will be substantially reduced compared to techniques involving meticulously gluing dowels to the model to form the ridges. In addition, a ridge pattern may be readily revised by removing portions of the flexible mesh sheet from certain regions of the exterior surface of the model, and/or adding additional flexible mesh sheets to other regions. Furthermore, due to the reduced duration and costs

associated with ridge formation, a large number of ridges may be formed on the exterior surface of the model. As a result, the ridges will establish grooves having a significant aggregate volume. Consequently, the number of vents (e.g., auto vents and/or parting line vents) may be significantly decreased, thereby substantially reducing or eliminating the possibility of flash formation and/or clogged vents. In certain embodiments, the grooves may have sufficient volume to accommodate all of the air displaced during the foam expansion process, thereby obviating the vents and substantially decreasing the costs associated with mold production.

[0022] FIG. 2 is a perspective view of an exemplary model and an embodiment of a flexible mesh sheet configured to establish grooves in a mold cavity formed from the model. As illustrated, a model 20 having a shape representative of a seat bottom cushion includes an exterior surface 22 having a variety of contours 24. The shape may be established by machining the model 20 from a solid block of material (e.g., wood, plastic, metal, etc.). As discussed in detail below, ridges are applied to the model to establish corresponding grooves within a mold cavity formed from the model. In the illustrated embodiment, the ridges are established by applying a flexible mesh sheet 26 to the exterior surface 22 of the model 20. The flexible mesh sheet 26 includes ridges 28 forming multiple cells 30, and establishing a repeating cellular pattern. Due to the flexibility of the mesh sheet 26, the ridges 28 will naturally follow the contours 24 of the exterior surface 22 as the sheet 26 is applied to the model 20. Consequently, the duration associated with establishing ridges on the model via the flexible mesh sheet may be significantly less than techniques involving meticulously gluing dowels to the exterior surface of the model to establish the ridges.

[0023] In the illustrated embodiment, an adhesive layer 32 is applied to the flexible mesh sheet 26. For example, the adhesive layer may be applied during the manufacturing process for the flexible mesh sheet, or immediately prior to applying the flexible mesh sheet to the exterior surface of the model. Once the adhesive layer is applied, the flexible mesh sheet 26 may be affixed to the exterior surface 22 of the model 20. After the adhesive has cured and/or hardened, the mold cavity may be formed from the model such that the ridges of the flexible mesh sheet form corresponding grooves within an interior surface of the mold cavity.

[0024] In the illustrated embodiment, the flexible mesh sheet 26 is applied to a first region of the exterior surface 22 of the model 20, and a second flexible mesh sheet 34 is applied to a second region. The size, shape and location of each sheet may be particularly configured to accommodate the air displaced during the foam molding process. For example, the mesh sheets may be particularly positioned to substantially reduce the possibility of void formation along the exterior surface of the foam cushion. While two flexible mesh sheets are included in the illustrated embodiment, it should be appreciated that alternative embodiments may include more or fewer mesh sheets. For example, certain embodiments may include 1, 2, 3, 4, 5, 6, or more flexible mesh sheets to establish the desired ridge pattern.

[0025] FIG. 3 is a top view of an embodiment of a cell 30 that may be employed within the flexible mesh sheet of FIG. 2. While the illustrated cell 30 is hexagonal, it should be appreciated that alternative embodiments may employ other cell shapes. For example, certain cells may be rectangular, triangular, pentagonal or circular, among other shapes. In the illustrated embodiment, the cell 30 has a width 36 and a ridge thickness 38. As will be appreciated, the cell width 36 and the ridge thickness 38 may be particularly selected to achieve a desired groove pattern within the interior surface of the mold cavity. For example, ridge thickness 36 may be increased to provide a larger groove volume, thereby enabling the grooves to accommodate additional displaced air. In addition, the cell width 36 may be decreased to establish tighter spacing between grooves, thereby further reducing the possibility of void formation during the foam molding process.

[0026] FIG. 4 is a top view of an embodiment of a mold cavity 40 formed from the model of FIG. 2. As discussed in detail below, the mold cavity 40 may be formed by applying material (e.g., plaster, a fiber glass/resin mixture, etc.) to the exterior surface of the model to form a pattern, packing sand around the pattern to form an impression, and casting the mold cavity from the impression (e.g., by pouring liquid metal into the sand impression). As a result of the casting process, the ridges of the flexible mesh sheet will form grooves 42 within the interior surface of the mold cavity 40. The grooves 42 are configured to accommodate air displaced during the foam molding process, and to facilitate air flow to vents, such as the illustrated auto vent 44. As

illustrated, the vent 44 is in fluid communication with one of the grooves 42, thereby enabling the displaced air to flow out of the mold cavity. Because the grooves 42 may be interconnected throughout the interior surface of the mold cavity 40, air from various regions of the cavity may be directed to a single vent, or a small number of vents spaced along the interior surface. As a result, the costs associated with mold production may be significantly lower than molds employing fewer separated grooves and a larger number of vents, such as molds formed by applying linear dowels to the exterior surface of the model. While an auto vent 44 is utilized in the illustrated embodiment, it should be appreciated that alternative embodiments may employ a parting line vent (i.e., a vent positioned at the parting line between mold cavities), either alone or in combination with an auto vent. Furthermore, it should be appreciated that certain embodiments may include grooves having sufficient volume to accommodate all of the air displaced during the foam molding process. In such embodiments, the vent 44 may be omitted, thereby further reducing the cost of mold construction.

[0027] FIG. 5 is a flow diagram of an exemplary method 46 for manufacturing a mold cavity. First, as represented by block 48, a model having a shape representative of a desired product (e.g., a seat bottom cushion, a seat back cushion, etc.) is formed. For example, a block of material (e.g., wood, plastic, metal, etc.) may be machined to achieve the desired shape. Next, a flexible mesh sheet having multiple ridges forming a repeating cellular pattern is trimmed to a desired shape, as represented by block 50. The flexible mesh sheet is then applied to an exterior surface of the model, as represented by block 52. In certain embodiments, a single sheet may be trimmed and applied to a desired region of the exterior surface of the model. Alternatively, multiple flexible mesh sheets may be trimmed and applied to different regions of the exterior surface (e.g., regions in which voids are more likely to form).

[0028] As represented by block 54, the mold cavity is then formed from the model such that the ridges of the flexible mesh sheet form corresponding grooves within an interior surface of the mold cavity. Because the grooves are formed by the flexible mesh sheet, the process of meticulously coupling dowels to the model to form grooves in the mold cavity is obviated, thereby substantially reducing the duration and costs

associated with mold production. In certain embodiments, a vent (e.g., auto vent or parting line vent) is coupled to the mold cavity such that the vent is in fluid communication with at least one groove, as represented by block 56. As previously discussed, the vent facilitates air flow out of the mold to enable expansion of the foam. However, it should be appreciated that alternative embodiments provide grooves having sufficient volume to accommodate all of the air displaced during the foam expansion process. In such embodiments, the vent may be omitted, thereby substantially reducing the cost of mold construction.

[0029] FIG. 6 is a flow diagram of an exemplary method 52 for applying a flexible mesh sheet to an exterior surface of a model. First, as represented by block 58, an adhesive layer is applied to the flexible mesh sheet. For example, the adhesive layer may be applied during the manufacturing process for the flexible mesh sheet, or immediately prior to applying the flexible mesh sheet to the exterior surface of the model. Once the adhesive layer is applied, the flexible mesh sheet is coupled to the exterior surface of the model via the adhesive layer, as represented by block 60. In certain embodiments, exposure to air and/or a reaction between chemicals in the adhesive layer will cause the layer to gel and harden, thereby bonding the flexible mesh sheet to the exterior surface of the model. Alternatively, heat may be applied (e.g., via an autoclave) to the flexible mesh sheet to activate the adhesive layer, as represented by block 62. Once the flexible mesh sheet is bonded to the model, the mold cavity may be formed such that the ridges of the flexible mesh sheet form corresponding grooves within an interior surface of the mold cavity.

[0030] FIG. 7 is a flow diagram of an exemplary method 54 for forming a mold cavity from a model. First, as represented by block 64, material is applied to the exterior surface of the model to form a pattern. For example, the material may include plaster, a fiber glass/resin mixture and/or any other suitable material capable of conforming to the contours of the model and the flexible mesh sheet. Once the material cures and/or hardens, the pattern, which is a negative of the model, is separated from the model. Sand is then packed around the pattern to form an impression, as represented by block 66. As will be appreciated, the sand impression is a negative of the pattern, i.e., a positive of the model. The pattern is then removed,

and the mold cavity is cast from the impression, as represented by block 68. For example, liquid metal (e.g., aluminum, steel, bronze, etc.) may be poured into the sand impression, thereby forming a negative of the impression. As a result, the ridges of the flexible mesh sheet will form corresponding grooves within the mold cavity, thereby enabling the mold cavity to accommodate the air displaced during the foam molding process.

[0031] While only certain features and embodiments of the invention have been illustrated and described, many modifications and changes may occur to those skilled in the art (e.g., variations in sizes, dimensions, structures, shapes and proportions of the various elements, values of parameters (e.g., temperatures, pressures, etc.), mounting arrangements, use of materials, colors, orientations, etc.) without materially departing from the novel teachings and advantages of the subject matter recited in the claims. The order or sequence of any process or method steps may be varied or re-sequenced according to alternative embodiments. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the invention. Furthermore, in an effort to provide a concise description of the exemplary embodiments, all features of an actual implementation may not have been described (i.e., those unrelated to the presently contemplated best mode of carrying out the invention, or those unrelated to enabling the claimed invention). It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation specific decisions may be made. Such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure, without undue experimentation.

CLAIMS:

1. A method of manufacturing a mold cavity, comprising:

forming a model having a shape representative of a desired product;

applying a flexible mesh sheet to an exterior surface of the model, wherein the flexible mesh sheet includes a plurality of ridges forming a repeating cellular pattern; and

forming the mold cavity from the model such that the plurality of ridges forms a corresponding plurality of grooves within an interior surface of the mold cavity.

2. The method of claim 1, wherein each cell of the repeating cellular pattern is substantially hexagonal.

3. The method of claim 1, wherein forming the model comprises machining the shape representative of the desired product from a block of material.

4. The method of claim 1, wherein applying the flexible mesh sheet to the exterior surface of the model comprises coupling the flexible mesh sheet to the exterior surface via an adhesive layer.

5. The method of claim 4, wherein the adhesive layer is applied to the flexible mesh sheet prior to applying the flexible mesh sheet to the exterior surface of the model.

6. The method of claim 4, comprising activating the adhesive layer via application of heat after applying the flexible mesh sheet to the exterior surface of the model.

7. The method of claim 1, comprising trimming the flexible mesh sheet to a desired shape prior to applying the flexible mesh sheet to the exterior surface of the model.

8. The method of claim 1, comprising applying a plurality of flexible mesh sheets to different regions of the exterior surface of the model.

9. The method of claim 1, wherein forming the mold cavity comprising applying material to the exterior surface of the model to form a pattern, packing sand around the pattern to form an impression, and casting the mold cavity from the impression.

10. The method of claim 1, comprising coupling a vent to the mold cavity such that the vent is in fluid communication with at least one groove.

11. A mold cavity prepared by a process, comprising:

forming a model having a shape representative of a desired product;

applying a flexible mesh sheet to an exterior surface of the model, wherein the flexible mesh sheet includes a plurality of ridges forming a repeating cellular pattern; and

forming the mold cavity from the model such that the plurality of ridges forms a corresponding plurality of grooves within an interior surface of the mold cavity.

12. The mold cavity of claim 11, comprising a vent coupled to the mold cavity and in fluid communication with at least one groove.

13. The mold cavity of claim 11, wherein each cell of the repeating cellular pattern is substantially hexagonal.

14. The mold cavity of claim 11, wherein the process comprises coupling the flexible mesh sheet to the exterior surface of the model via an adhesive layer.

15. The mold cavity of claim 11, wherein the process comprises applying a plurality of flexible mesh sheets to different regions of the exterior surface of the model.

16. A product formed by a mold cavity prepared by a process, comprising:

forming a model having a shape representative of the product;

applying a flexible mesh sheet to an exterior surface of the model, wherein the flexible mesh sheet includes a plurality of ridges forming a repeating cellular pattern; and

forming the mold cavity from the model such that the plurality of ridges forms a corresponding plurality of grooves within an interior surface of the mold cavity.

17. The product of claim 16, wherein the product is formed by injecting a foamable liquid into the mold cavity.

18. The product of claim 16, wherein the mold cavity comprises a vent coupled to the mold cavity and in fluid communication with at least one groove.

19. The product of claim 16, wherein each cell of the repeating cellular pattern is substantially hexagonal.

20. The product of claim 16, wherein the process comprises coupling the flexible mesh sheet to the exterior surface of the model via an adhesive layer.

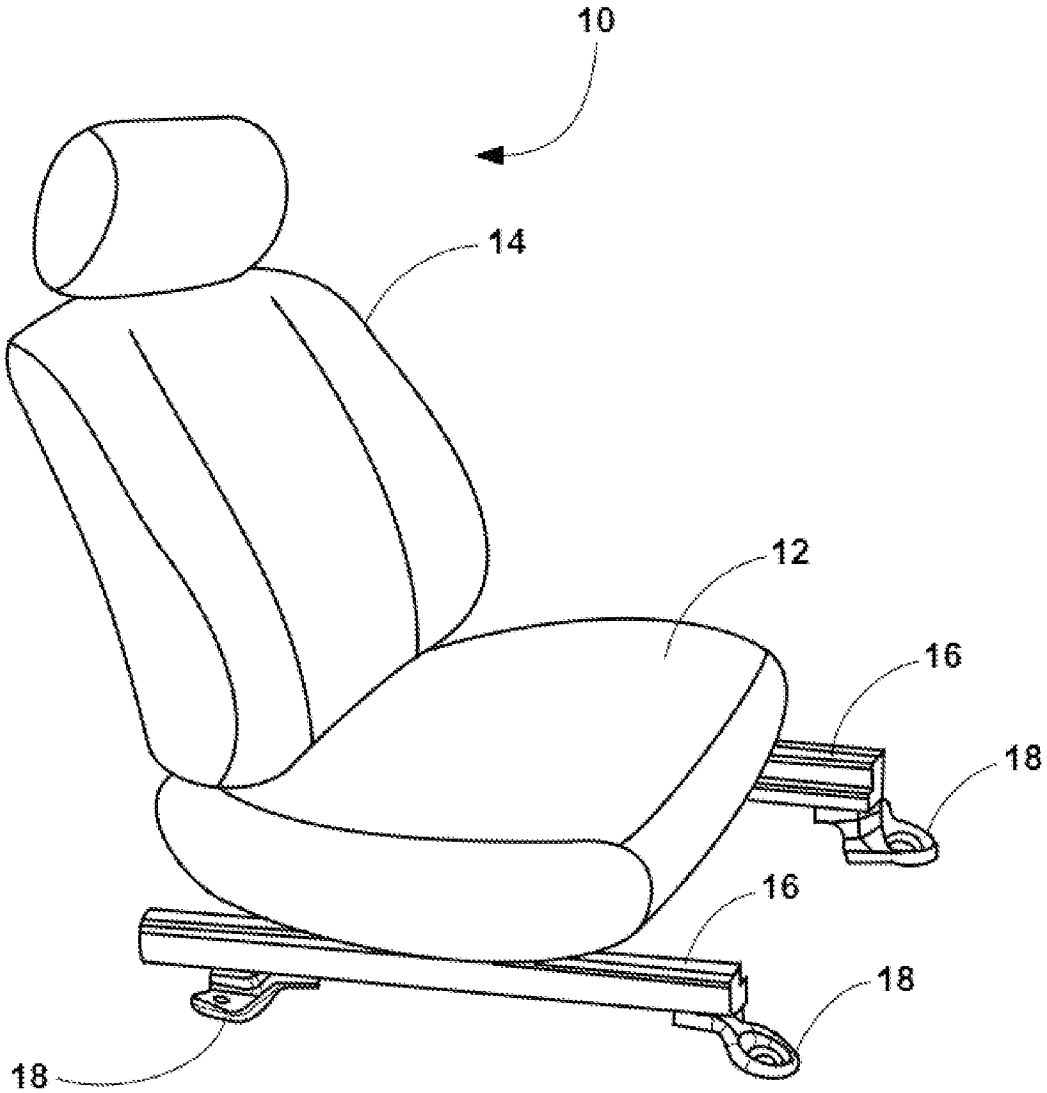


FIG.1

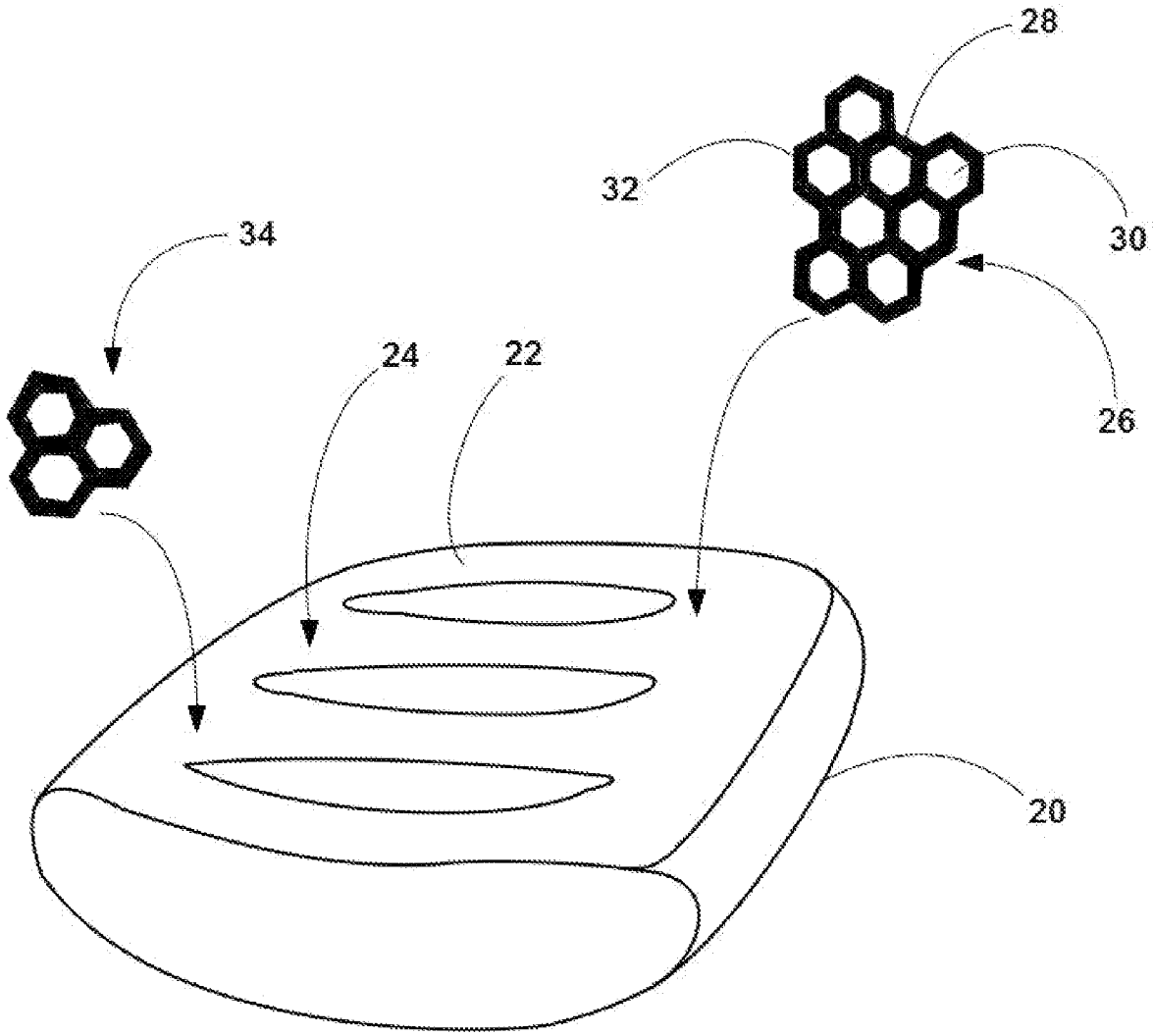


FIG.2

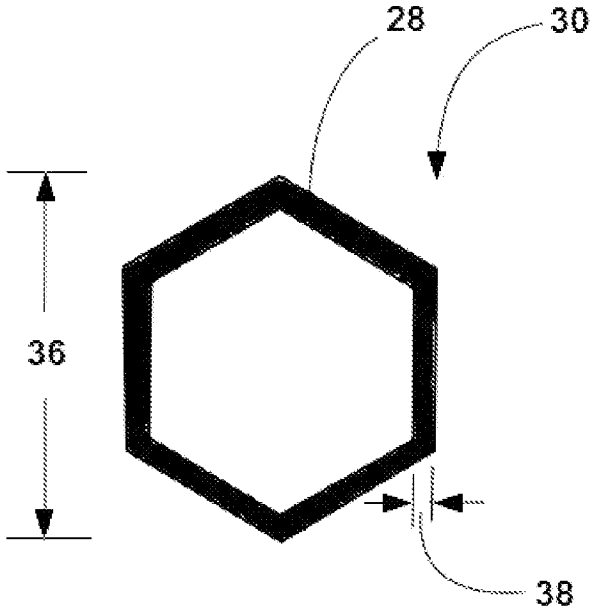


FIG.3

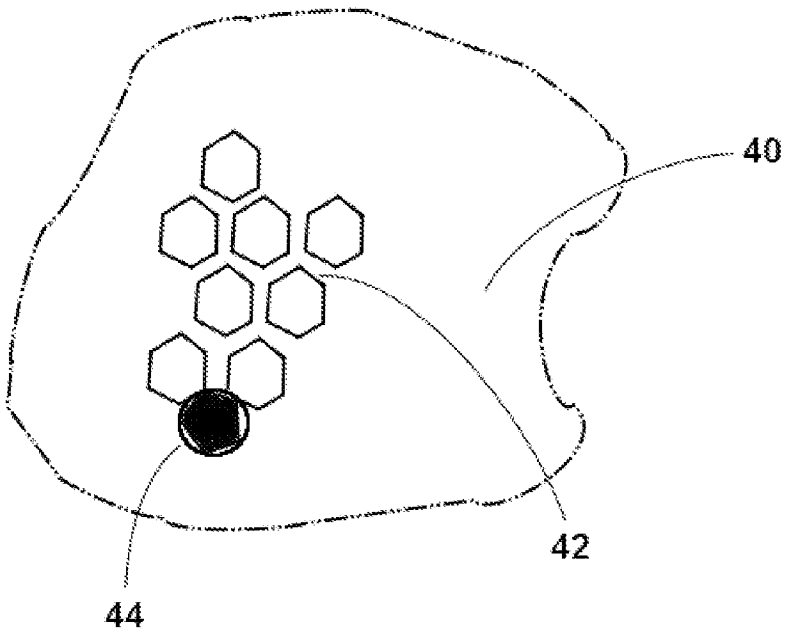


FIG.4

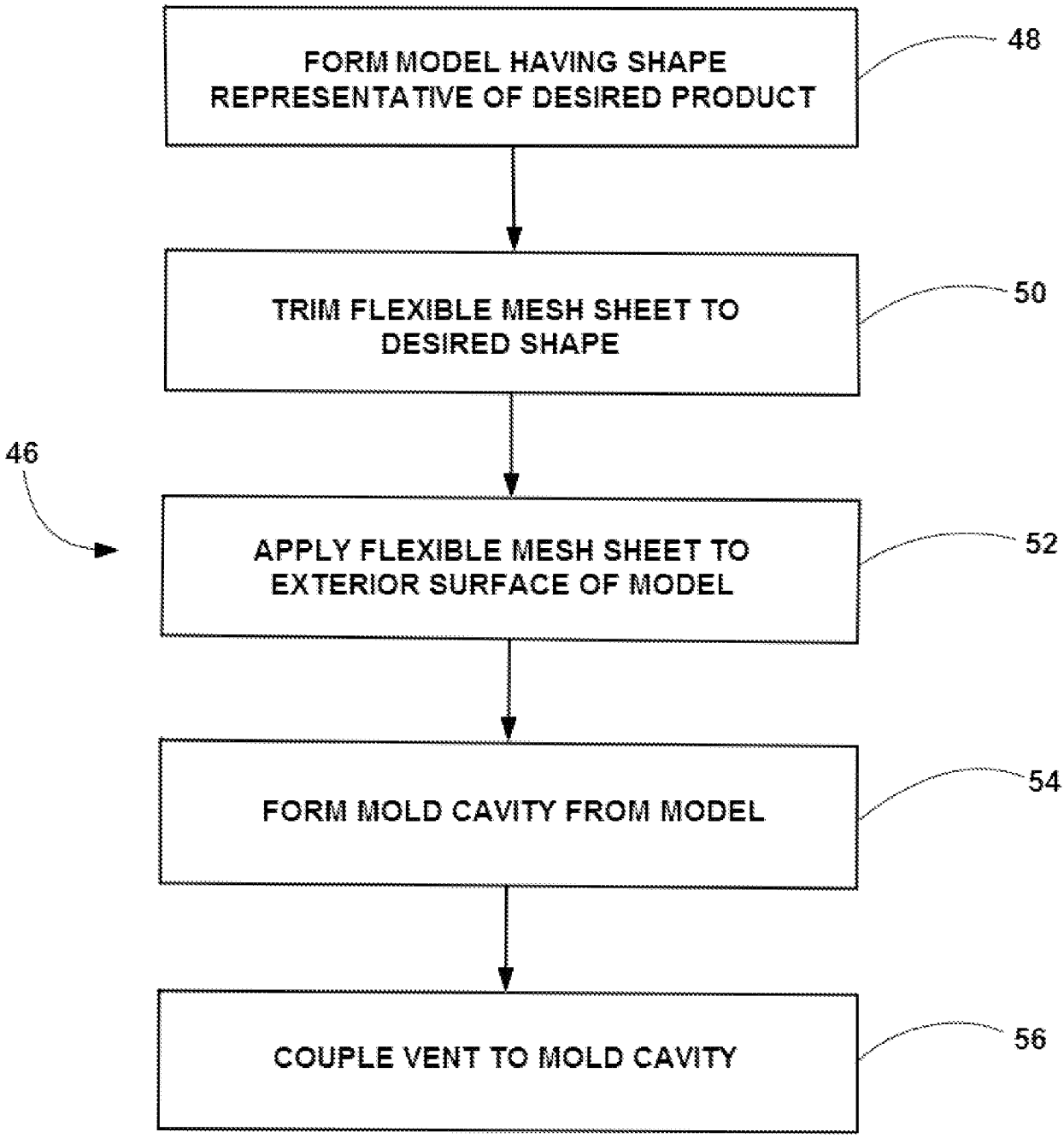

FORM MODEL HAVING SHAPE REPRESENTATIVE OF DESIRED PRODUCT
48
TRIM FLEXIBLE MESH SHEET TO DESIRED SHAPE
50
46
APPLY FLEXIBLE MESH SHEET TO EXTERIOR SURFACE OF MODEL
52
FORM MOLD CAVITY FROM MODEL
54
COUPLE VENT TO MOLD CAVITY
56

FIG.5

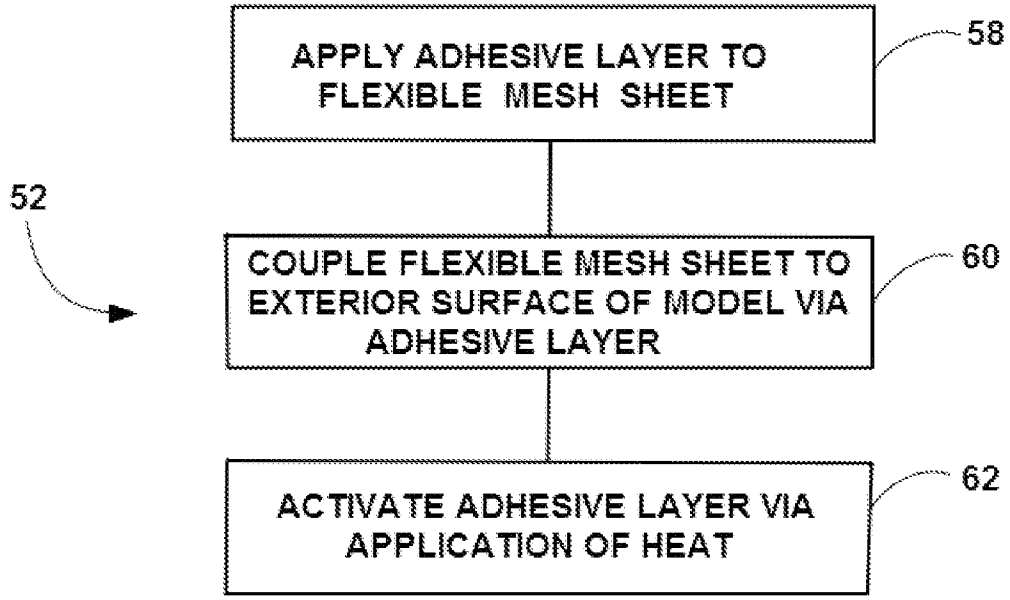

APPLY ADHESIVE LAYER TO FLEXIBLE MESH SHEET
58
52
COUPLE FLEXIBLE MESH SHEET TO EXTERIOR SURFACE OF MODEL VIA ADHESIVE LAYER
60
ACTIVATE ADHESIVE LAYER VIA APPLICATION OF HEAT
62

FIG.6

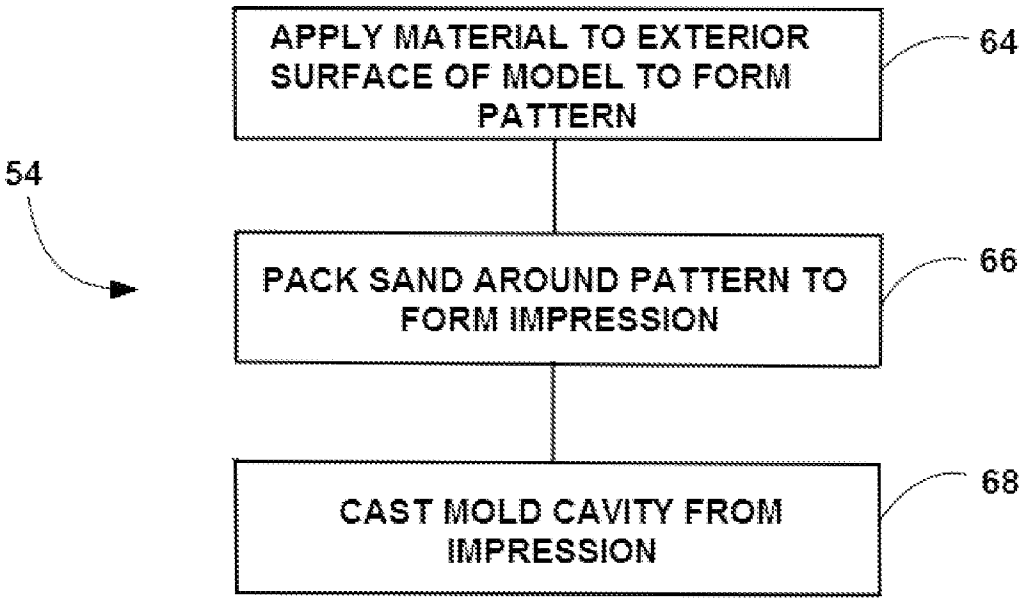

APPLY MATERIAL TO EXTERIOR SURFACE OF MODEL TO FORM PATTERN
64
54
PACK SAND AROUND PATTERN TO FORM IMPRESSION
66
CAST MOLD CAVITY FROM IMPRESSION
68

FIG.7

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2012/039430

A. CLASSIFICATION OF SUBJECT MATTER
INV. B29C44/58 B29C44/12 B29C33/38
ADD.

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)
B29C

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 438 337 A (SEKISUI PLASTICS [JP]) 21 November 2007 (2007-11-21) paragraphs [0019] - [0029], [0041], [0043] -----	1-20
X	FR 2 736 823 A1 (ROUX GEORGES [FR]) 24 January 1997 (1997-01-24) page 4, line 25 - page 5, line 1 -----	11-20

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"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)

"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

"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

"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

"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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 August 2012	06/09/2012

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Pipping, Lars

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2012/039430

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB 2438337 A	21-11-2007	CN 101102859 A	09-01-2008
		DE 112006000437 T5	31-07-2008
		GB 2438337 A	21-11-2007
		JP 4434987 B2	17-03-2010
		JP 2006231633 A	07-09-2006
		US 2008141520 A1	19-06-2008
		WO 2006090738 A1	31-08-2006
FR 2736823 A1	24-01-1997	NONE	