



(43) International Publication Date
16 September 2010 (16.09.2010)

(10) International Publication Number
WO 2010/103096 A1

(51) International Patent Classification:
B65G 15/34 (2006.01) **C08L 23/16** (2006.01)

(21) International Application Number:
PCT/EP2010/053169

(22) International Filing Date:
12 March 2010 (12.03.2010)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
09155128.3 13 March 2009 (13.03.2009) EP

(71) Applicant (for all designated States except US): **HABA-SIT AG** [CH/CH]; Römerstrasse 1, CH-4153 Reinach (CH).

(72) Inventor; and

(75) Inventor/Applicant (for US only): **WRIGHT, Marshall** [GB/CH]; Langer Zweig 6, CH-4244 Röschenz (CH).

(74) Agents: **BOHEST AG** et al.; P.O. Box 160, CH-4003 Basel (CH).

(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, RO, RS, RU, 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.

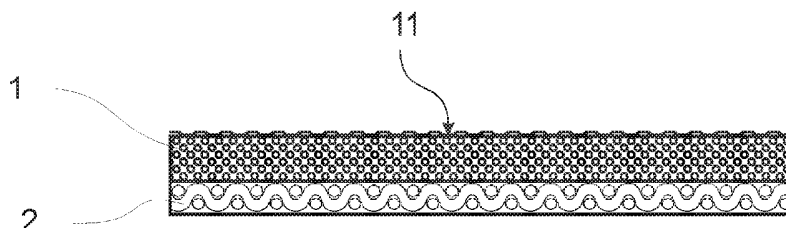
(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT,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

Published:

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

(54) Title: BELT COMPRISING A LAYER OF FOAMED SOFT THERMOPLASTIC ELASTOMER

Fig. 1



(57) Abstract: A belt comprising a foamed layer (1, 3, 6, 17, 23), characterised in that this foamed layer (1, 3, 6, 17, 23) contains a foam of a thermoplastic elastomer which in the unfoamed state has a Shore A hardness of at the most 85. The thermoplastic elastomer may in particular be a substantially random ethylene/C₃₋₁₂- α -olefin copolymer, optionally blended with a compatible thermoplastic; a thermoplastic elastomeric block copolymer such as TPE-U; a blend of thermoplastics and elastomers; an alloy of thermoplastics and elastomers; a thermoplastic elastomeric ionomer; a blend of TPE-U with another thermoplastic elastomer; or a blend of TPE-U with an elastomer. The belt may in particular be a conveyor belt, a transport belt, a treadmill belt or a printing blanket.

BELT COMPRISING A LAYER OF FOAMED SOFT THERMOPLASTIC
ELASTOMER

The present invention concerns belts with foamed layers.

5 Soft belts are customarily made on the one hand of a
PVC containing a plasticizer such as phthalates. This brings
about the problems of leaching of the plasticizer out of the
PVC and its potential toxicity. On the other hand soft belts
have been made from rubbers. These have good physical
10 properties but have the disadvantage of a relatively high
cost.

WO 2008/113195 discloses a treadmill belt, which may
have an intermediate layer, or top layer, which may be of a
thermoplastic foam.

15 US 5,332,080 discloses an apparatus for conveying
glass panes, the apparatus having an endless conveying
element having supporting surfaces for the glass panes which
may be made of a plastic or elastomer of Shore A hardness
between 15 and 50, preferably between 30 and 40, and which
20 may be a foamed polyurethane having Shore A hardness of about
40, i.e. after foaming.

EP 1 717 169 A discloses a belt having a stretchable
fabric disposed on either the inner or outer side of a single
tension member and unfoamed thermoplastic polyurethane
25 elastomer layer(s) with Shore A hardness of 85, sandwiched
between the stretchable fabric(s) and the tension member.

Such a belt is tested in a testing apparatus having pulleys of 40 mm and 15 mm.

The present invention has the task to provide an improved soft belt.

5 This task is solved according to the present invention by a belt comprising a foamed layer, characterised in that this foamed layer contains a foam of a thermoplastic elastomer, which in the unfoamed state has a Shore A hardness of at the most 85. Preferred embodiments of the present
10 invention will be apparent from the dependent claims.

By the term "belt" is understood in the context of the present invention in particular a conveyor belt, a transport belt, a treadmill belt or a printing blanket.

15 The thermoplastic elastomers useful for the instant invention have a Shore A hardness of at the most 85 before foaming. Preferably they have a Shore A hardness of about 40 to about 70 and more preferably of about 50 to about 60.

20 These Shore A hardness boundary or range values are understood in the context of the invention as the hardness of the thermoplastic elastomeric material, including any possible fillers and additives admixed thereto, but in the unfoamed state. In order to do so a specimen of the layer of the belt to be analysed is separated from the belt. If the layer is already foamed then it is re-melted to remove foam
25 bubbles and gas and the melt re-solidified to form a solid, unfoamed layer of suitable thickness, which should be a minimum of 6.4 mm, and polished to form a flat surface

thereupon, if necessary. The hardness measurement is done using a hardened steel rod of 1.1 mm diameter, with a truncated 35° cone of 0.79 mm diameter, and using a pressure of 0.822 kg (8.064 Newton) for 15 seconds.

5 Exemplary thermoplastic elastomers with such Shore A hardness can be divided into several classes:

1) Substantially random ethylene/C₃₋₁₂- α -olefin copolymers. Examples of the α -olefins are 1-propene, 1-butene, 1-
10 pentene, 1-hexene and 1-octene; the most preferred being 1-octene. These copolymers can be produced by so-called "single-site" catalysts in combination with polymeric methyl aluminoxane [MAO, -(Me-Al-O)_n-] as co-catalyst. Preferred
15 examples of such catalysts are the "single-site" catalysts from Dow Chemicals known under the name INSITE™ and those from Exxon Mobil Chemicals known under the name EXXPOL®. Examples of thermoplastic elastomeric ethylene/ α -olefin
copolymers are the Affinity™, Engage® and Versify™
copolymer families (Dow) or the Exact™ copolymer family
20 (DEX-Plastomers). One or more of these random copolymers may optionally be blended with a compatible thermoplastic polyamide (TPA) or thermoplastic polyurethane (TPU) and/or with a compatible thermoplastic polyolefin (TPO, such as polyethylene or polypropylene).

25

2) Thermoplastic elastomeric block copolymers. A first subgroup within these are block copolymers of oligomers of styrene and of oligomers of other olefinic monomers, also called styrenic block copolymers (SBC's). Examples are
30 styrene-butadiene-styrene (SBS), styrene-isoprene-styrene

(SIS), styrene-ethylene/butylene-styrene (SEBS) and styrene-ethylene/propylene-styrene (SEPS) block copolymers. Specific examples thereof are the Styroflex® copolymer family (BASF), the Kraton® copolymer family (Kraton) and the Megol®
5 copolymer family (Api S.p.A.). A second subgroup are copolymers of hard blocks of medium density polyethylene and of soft blocks of ethylene/ α -olefin copolymer, in particular of ethylene/1-octene copolymer, the latter as outlined under above 1). An example is the Infuse® family of copolymers
10 (Dow). A third subgroup are TPE-U's, such as copolymers of polyester diols or polyether diols with diisocyanates, or TPE-U's based on polycarbonate. The polyester diol may be formed from adipic acid and butanediol; the polyether diol may be for example a polyaddition adduct of ethylene oxide
15 and/or propylene oxide; and the diisocyanate may be in particular diphenylmethane 4,4'-diisocyanate. A specific example for the TPE-U is the Onflex™ U family (GLS Corporation); a more specific example for TPE-U's in the form of copolymers of polyester diols and diisocyanates are the
20 Laripur family, in particular the "series 25" subfamily (Coim S.p.A.). The TPE-U can also be a TPE-U based on polycarbonate. Examples here are the Pellethane® copolymer family (Dow Chemical). A fourth subgroup are TPE-E's such as the Arnitel® (DSM) and Hytrel® (DuPont) copolymer families.
25 A fifth subgroup are TPE-A's. All these may optionally be blended with a compatible thermoplastic selected from those outlined below under 3).

3) Blends of thermoplastics and true (crosslinked or
30 vulcanized) elastomers, wherein the elastomer is miscible with thermoplastic in its molten state, or is dispersible

therein. Examples for the thermoplastics in these blends include, but are not limited to: thermoplastic PA's such as PA 6, PA 11, PA 12, PA 66, PA 69, PA 610, PA 612, PA 6T, PA 6-3-T, PA MXD6, PE's such as for example PET or PBT, TPU's
5 useful for producing soft foamed materials. Further examples of thermoplastics are TPO such as for example polyethylene or polypropylene; and homo- or copolymers of vinyl chloride, such as PVC and vinyl chloride/ethylene/vinyl acetate copolymers (VCEVAC). The elastomer in these blends has
10 already been crosslinked using suited co-monomers, or already has been vulcanized, before mixing with the thermoplastic. Examples for the crosslinked or vulcanized elastomer in these blends include, but are not limited to, natural rubber, polyisoprene, polybutadiene, styrene-butadiene rubber (SBR),
15 nitrile-butadiene rubber (NBR), ethylene-propylene-diene rubber (EPDM) and acrylate rubbers. Specific examples for the blends are blends of homo- or copolymers of vinyl chloride with elastomers, such as PVC/NBR or VCEVAC/NBR, the PVC homopolymer component in these being optionally softened with
20 an appropriate softener (such as phthalates, e.g. dioctylphthalate, or esters of aliphatic dicarboxylic acids) in order to obtain the necessary Shore A hardness for the unfoamed blend (an example of a softened PVC/NBR blend is Apilon 33 of Api S.p.A.); blends of polyethylene or
25 polypropylene with EPDM, particularly polypropylene/EPDM blends with a mass fraction of about 35 to 45 % by weight, based on the blend, of polypropylene; and blends of thermoplastic polyamides with elastomers, such as PA6/EPDM, PA6/SBR, PA66/EPDM, PA66/SBR, PA11/EPDM, PA11/SBR, PA12/EPDM
30 and PA12/SBR, the PA component in these being optionally softened with an appropriate softener (such as aromatic sulfonamides, e.g. N-butylbenzenesulfonamide) in order to

obtain the necessary Shore A hardness for the unfoamed blend.

4) Thermoplastic elastomer alloys. These are similar to the blends exemplified under above 3), except that the elastomer is crosslinked in situ during the mixing with the molten thermoplastic, during which also some chemical bonding between elastomer and thermoplastic may occur. A first subgroup among these are thermoplastic vulcanizates (TPV's). Here, the crosslinkable elastomer is a vulcanizable elastomer containing olefinic unsaturations. Examples thereof are natural rubber, polyisoprene, polybutadiene, styrene-butadiene rubber (SBR), nitrile-butadiene rubber (NBR) and ethylene-propylene-diene rubber (EPDM). The vulcanization may be done during mixing with the thermoplastic using a suited curing agent such as sulfur, sulfur compounds or peroxides. The thermoplastic component for TPV's is preferably a saturated polyolefin, such as polyethylene or polypropylene. Examples are the Santoprene®, Geolast® (Monsanto), Alcryn® (DuPont) and Versalloy™ (GLS corporation) alloys.

20

5) Thermoplastic elastomeric ionomers. These are preferably copolymers of an olefinic monomer (in particular ethylene) and an α,β -ethylenically unsaturated C₃₋₆carboxylic acid optionally with a co-polymerized softening olefinic monomer which may be selected from vinyl esters of saturated C₂₋₆-carboxylic acids (in particular vinylacetate) and C₁₋₄alkylvinyl ethers (in particular ethylvinyl ether), and wherein the carboxylates of the ionomer have at least partially been neutralised with metal ions derived from alkali metals (in particular from sodium), from zinc and from aluminium. An example is poly(ethylene-co-methacrylate), an example being the Surlyn® copolymer family (DuPont).

30

6) Blends of TPE-U with another thermoplastic elastomer or with an elastomer. A preferred subgroup among the blends of TPE-U and thermoplastic elastomer are blends of TPE-U with styrenic block copolymers, in particular with SEBS. A

5 specific example for the latter are the Onflex™ U 5300 family (GLS Corporation). Examples for the blends of TPE-U and elastomer are the Desmoflex® family (Bayer) and the Versollan™ family (GLS corporation).

10 Preferably, if the thermoplastic elastomer is TPE-U, then it is blended with a compatible thermoplastic, another thermoplastic elastomer or with an elastomer. .

The foamed layers, in particular the foamed cover layer, each contain a foamed thermoplastic elastomer which
15 consists preferably of at least 50 percent by weight, more preferably of at least 75 percent by weight, even more preferably of at least 90 percent by weight and yet even more preferably at of least 95 percent by weight, based on the layer, of a thermoplastic elastomer as exemplified above,
20 whereby the remainder of the layer being residual fractions of blowing agent, gas and optional further additives. Such additives are for example:

a) auxiliaries to improve the properties of the finished
25 products such as for example UV and heat stabilizers; flame retardants; colorants; antibacterial or mold-killing additives; and

b) fillers as extenders to save plastics and thereby lower
30 costs and/or for changing the electrical conductivity and dimensional stability and/or for reducing thermal expansion.

In particular elongate or fibrous additives enhance strength.

The belt of the present invention may preferably include one or more traction layer(s), preferably exactly two traction layers, each preferably containing a textile fabric, embedded or encased in a plastic, or consisting solely of a textile fabric. This textile fabric can be either a woven fabric or a knit fabric (for example a drawn-loop knit fabric or a formed-loop knit fabric); alternatively, it can also be a nonwoven fabric such as for example a fibrous nonwoven web or a laid scrim. The fabric is preferably a woven fabric. Some more preferred configurations are woven fabrics made of multifilament warp with monofilament or with multifilament weft fibres; or fabrics made of staple warp with monofilament or multifilament weft fibres or with staple weft fibres. The most preferred configuration is staple or multifilament warp with monofilament weft. The preferred material for all types of fibres is polyester.

Preferably on the one hand the foamed thermoplastic elastomer layer forms the cover layer of the belt of the present invention, lying more preferably on the traction layer or, if two or more traction layers are provided, on the upper traction layer (when two traction layers are provided) or on the topmost traction layer (when more than two traction layers are provided). This foamed cover layer may optionally be provided on its top side with a profile, in order to make the belt useful for a belt running steeply inclined. These profiles can be applied by embossing for example. The topmost layer (the top layer or the covering layer) may optionally also have antistatic properties. The latter can be achieved, as customary in the art, by including conductive fibres or

filaments into the textile fabric of the traction layer(s) and/or by admixing pulverulent, fibrous or fibril-shaped electrically conductive materials (for example graphite, aluminum, silver, copper, nickel or polypyrrol) to the material of one of the other layers, such as the topmost layer.

Preferably on the other hand the belt of the invention comprises two traction layers (a lower traction layer and an upper traction layer) and the layer of foamed thermoplastic elastomer forms an intermediate layer in between these.

More preferably the belt of the invention comprises two traction layers (a lower traction layer and an upper traction layer) and two layers of a thermoplastic elastomer. One of these forms a cover layer and the other one forms an intermediate layer. At least one of the two layers of thermoplastic elastomer is foamed; preferably both of the thermoplastic elastomer layers are foamed.

The layers of the belt of the present invention are arranged on top of each other. This means in the context of the present invention that the layers are bonded together either directly, for example by heat and pressure, or by co-use of a customary adhesive. It is preferred that any cover layer made of a foamed thermoplastic elastomer be adhered to an underlying traction layer without the use of any adhesive layers, using the material of the cover layer and/or of any underlying thermoplastic or thermoplastic elastomeric layers, whether foamed or unfoamed, as the hotmelt adhesive. It is also preferred that any intermediate layer between two traction layers, made of a thermoplastic or thermoplastic

elastomeric and foamed or unfoamed, be used as a hotmelt adhesive for adhering the intermediate layer to the two traction layers.

5 In order to achieve a direct bonding (i.e. without extra adhesive layers) between traction layers and the other layers lying atop of them or being arranged in between them it is preferred that the material pairs of adjoining layers be chosen appropriately. A particularly preferred material
10 pairing is to use a polyester, in particular a spun polyester, for the fibres of the fabric of the traction layer(s) and to use a blend of a substantially random ethylene/C₃₋₁₂- α -olefin copolymer of (in particular wherein the C₃₋₁₂- α -olefin is 1-octene) and a thermoplastic polyamide
15 (TPA) or thermoplastic polyurethane (TPU), optionally further blended with a compatible thermoplastic polyolefin (such as polyethylene or polypropylene).

 The thicknesses of any layers containing a foamed
20 thermoplastic elastomer is preferably in the range of 0.4 to 1.5 mm. For such a foamed cover layer the thickness is preferably in the range of 0.4 to 0.8 mm; and for such a foamed intermediate layer the thickness is preferably in the range of 0.7 to 1.5 mm. The overall thickness of the belt of
25 the invention is preferably in the range of 2.5 to 5.5 mm, preferably in the range of 3.0 to 4.5 mm.

 The thicknesses of the individual layers of the belt of the invention can be determined either on the belt itself or after its separation into the individual layers (cutting
30 open, milling off or detaching of layers). However, it may happen that one of the layers does not have a geometrically

sufficiently clear shape. In this case, instead of the geometric thickness, the thickness h can be determined as the quotient of the weight per unit area of the layer, G_L , (kg/m^2) and the mass-average density of all materials in the layer, ρ , (kg/m^3):

$$h = \frac{G_L}{\rho} = \frac{G_L}{\frac{\sum_{i=1}^N m_i \rho_i}{\sum_{i=1}^N m_i}}$$

where m_i is the amount of the i -th material of the layer (kg) and the summing is over all N materials occurring in the layer.

It is preferred for the foamed layers, in particular if it is a cover layer, that each of these consists of a thermoplastic elastomer foam having a degree of foaming in the range from about 5 to about 60 percent, preferably in the range from about 10 to about 40 percent. In the context of the present invention the "degree of foaming" defines the volume fraction the gas bubbles contribute to the overall volume of the thermoplastic elastomer foam. The degree of foaming is very simple to determine via a measurement of the densities in the foamed and unfoamed state:

$$r = \frac{(\rho_u - \rho_g)}{\rho_u} \times 100$$

In this formula, r is the degree of foaming in percent, ρ_u is the density of the unfoamed thermoplastic elastomer as a homogeneous mixture with all further

facultative additives such as for example dyes, and ρ_g is the density of an equal amount of the same thermoplastic elastomer mixture in the form of the blown foam.

All the foamed layers of the belt of the present invention can be produced by foaming a thermoplastic elastomeric material.

Foaming can firstly be carried out by direct admixture of a blowing agent to the thermoplastic elastomer material. The blowing agent may be a physical blowing agent. Examples of physical blowing agents are chlorofluorocarbons such as for example Frigen, Kaltron, Freon, Frigen, R11 and R12; hydrofluoroalkanes such as for example HFA 134 or HFA 227; and aliphatic linear, branched or cyclic (C_4 - C_8)-hydrocarbons such as for example C_5 -hydrocarbons (for example n-pentane, isopentane, neopentane, cyclopentane); C_6 -hydrocarbons (for example n-hexane, isohexane, methylcyclopentane, cyclohexane), C_7 -hydrocarbons (for example n-heptane, isohexane, methylcyclohexane, cycloheptane) and C_8 -hydrocarbons (for example octane, cyclooctane, isooctane, 1,2-, 1,3- or 1,4-dimethylcyclohexane). These hydrocarbons can be used in pure form or as hydrocarbon fractions of appropriately delimited boiling range, in which the respective hydrocarbons occur more or less dominantly (petroleum ether fractions). Further examples are blowing agents which are gaseous at room temperature, i.e. about 25°C, examples being N_2 , CO_2 , methane or argon; water; halogenated hydrocarbons such as for example dichloromethane, perchloroethylene and 1,1,1-trichloroethane; and low-boiling (i.e. boiling range about 60-100°C) alcohols such as for example methanol, ethanol, propanol, isopropanol and tert-

butanol. On the other hand, the blowing agent may also be a chemical blowing agent; chemical blowing agents only release the blowing gas, in particular nitrogen or carbon dioxide, upon heating. Examples of useful chemical blowing agents are
5 azo compounds, such as for example AIBN; hydrazine derivatives, such as for example benzenesulfonyl hydrazine; N-nitroso compounds; and easily decarboxylable carboxylic acids such as for example β -keto carboxylic acids. Physical blowing agents are preferred according to the present
10 invention. The blowing agent is preferably selected such that it mixes very readily with the thermoplastic elastomer material to be foamed. This means that apolar thermoplastic elastomer materials, for example, an apolar blowing agent such as one of the above gaseous blowing agents or one of the
15 above hydrocarbons or chlorofluorocarbons is used. On the other hand, water or one of the above alcohols can be used as a blowing agent for a more polar or hydrophilic thermoplastic elastomers. The amount of blowing agent is primarily determined by the desired degree of foaming. It may
20 preferably be in the range from about 1 to about 10 percent by weight, based on the total amount of the thermoplastic elastomer to be foamed.

Foaming may secondly also be carried out by admixing so-called "expandable microspheres" to the thermoplastic
25 elastomer material. Expandable microspheres have been known for a long time. They are formed by surrounding one of the above-exemplified, preferably physical blowing agents (in particular a water-insoluble blowing agent being liquid room temperature such as for example the abovementioned
30 hydrocarbons, hydrofluoroalkanes or chlorofluorocarbons) by means of aqueous emulsion polymerization with a polymeric

casing, for example of copolymer of acrylate/methacrylate and vinyl chloride. In the process, the blowing agent becomes encapsulated in the polymeric skin to form the said microspheres.

5 For the foaming it is preferred on the one hand that either the blowing agent be added in free form to the thermoplastic elastomer and the foaming be carried out using extrusion coating with simultaneous application to the supporting layer, such as one of the traction layers. It is
10 preferred on the other hand to perform the foaming separately in an extruder, in which case the blowing agent is preferably added in the form of the abovementioned expandable microspheres and the foamed first layer thus obtained is subsequently applied in a second operation to the supporting
15 layer by calendering.

The bonding together of foamed layers and traction layers can be done by calendering, extrusion coating or laminating. These methods are per se all known to the person skilled in the art.

20 In an alternative process for producing a belt of the present invention containing a layer of foamed thermoplastic elastomer comprising at least about 50% of blended thermoplastic PVC (as exemplified under the blends of above section 3), a dispersion of the PVC/elastomer blend in a
25 plasticizer, also containing a blowing agent of the type and in amounts as described above, is prepared. Useful plasticizers include for example phthalate plasticizers (e.g. dioctyl phthalate, diisooheptyl phthalate, di-2-ethylhexyl phthalate, diisooctyl phthalate, dicyclohexyl phthalate,

benzyl butyl phthalate or mixed diesters of phthalic acid with C₆-C₁₁-alkanols, where the alkanol may be primary or secondary); phosphoric acid esters (e.g., tri-2-ethylhexyl phosphate, triheptyl phosphate or tri-2-ethylpentyl phosphate) or low-viscosity (i.e., preferably ≤ 1000 mPa·s at room temperature) polyesters, obtainable from C₃-C₉-dicarboxylic acids (for example malonic acid, 1,4-butanedioic acid, 1,5-pentanedioic acid, adipic acid, azelaic acid, suberic acid or sebacic acid) and C₃-C₈-alkanediols (for example 1,2-propylene glycol, 1,3-propylene glycol, 1,4-butanediol). The dispersion may optionally have added to it further additives such as stabilizers, pigments or fillers. Such a dispersion, apart from the blowing agent additionally present, is comparable to the dispersions known in the art as plastisols. In the case of this beforehand-prepared dispersion the amount and type of plasticizers is chosen such that the dispersion has a pasty consistency. This dispersion is applied uniformly, for example with a doctor blade or by means of a coating roll, to the top side of a supporting layer, such as a traction layer, of the belt or intermediate compound, and the applied layer is foamed up to the desired degree of foaming by heating.

The belt of the present invention is preferably made endless. The belt can be made endless, for example, by direct welding, or by using the material of the foamed layer(s) as a hot-melt adhesive for bonding together, in which case optionally an additional adhesive, for example an additional hot-melt adhesive, may be co-used. Preferred is the welding or adhering without co-use of an additional adhesive. In these two preferred cases, the joint formed as the two ends are joined together consists of the same material as the

thermoplastic elastomer foam. To obtain this endless belt, a layered composite which already includes all required layers (as described above) is, if necessary, firstly cut to a suitable length. The ends thus obtained can then be end-
5 joined using any end joints known in the field of conveyor belts, examples being finger joints, wedge joints, overlap joints and step joints.

By the foaming the apparent softness of the thermoplastic elastomer is reduced even further than what would be
10 expected by the mere density reduction due to the foaming, which density reduction is used in the above described calculation of the degree of foaming. This in turn reduces the longitudinal stiffness of the belt of the invention, the energy requirement and the weight per unit thickness, and at
15 the same time compensates for the relatively high cost of the thermoplastic elastomer. Application of a foamed thermoplastic elastomer layer onto either the belt surface as a cover layer to provide a cushioning effect, or inclusion of such a foamed intermediate layer between its two traction
20 layers, allows compression of the intermediate layer during flexing, thereby reducing stress on the cover layer (whether foamed or not) and increasing longitudinal flexibility of the belt of the invention, which in turn leads to reduced energy consumption to drive the belt. Incorporation of both a cover
25 layer and an intermediate layer of a foamed thermoplastic elastomer gives a combination of both properties. The degree of longitudinal flexibility is surprising considering the relatively high belt thickness. The belt of the invention can withstand even nosebar application, such as at a
30 pulley/nosebar of down to 14 mm, without cracking and without separation of the layers. This is not possible with

conventional PVC and rubber belt constructions of similar thickness which are insufficiently flexible. The exceptional lengthwise flexibility combined with low density allows a relatively high belt thickness and this in turn gives high lateral rigidity, which in turn allows for a very stable running of the belt. This implies that it should be possible to make thicker belts still capable of negotiating small diameters, thereby increasing lateral stiffness. These belts should not appear "flimsy" as do prior art "soft" belts. In the belts of the invention it is possible and preferred that the thermoplastic elastomer used for the foam is devoid of plasticizers.

In the following the belt of the present invention and its production will now be described more in detail by means of illustrative embodiments with reference to the accompanying figures, of which

figures 1,2 show two versions of the belt of the present invention;

figure 3 shows a schematic view of an extruder useful for the production of the thermoplastic elastomer foams;

figure 4 shows schematically the production of a belt of the present invention from an intermediate layer of foamed thermoplastic elastomer and a lower traction layer by calendering and the subsequent addition of an upper traction layer, also by calendering;

and

figure 5 shows schematically the production of a belt of the present invention by extrusion coating of a traction layer with a foamed coating layer.

The belt of figure 1 includes a cover layer 1 of a foamed thermoplastic elastomer having Shore A hardness of 55 before foaming (blend of elastomer and thermoplastic polyurethane, Versollan™ RU 2204X-1). Its degree of foaming is about 20%, the foaming having been brought about by means of a physical blowing agent (Freon). The thickness of the cover layer 1 before embossing is about 0.6 mm. The cover layer 1 is arranged by extrusion coating on top of a traction layer 2 without use of any adhesive and is then embossed to give a profiled surface 11. The traction layer 2 consists of a woven polyester fabric having a twill weave, in which the warp threads are multifilaments of about 1100 dtex and the weft threads are monofilaments of 0.25 mm diameter. The thickness of the traction layer 2 is about 0.6 mm.

The belt of figure 2 includes a cover layer 3 of a foamed thermoplastic elastomer having Shore A hardness of 55 before foaming (Versollan™ RU 2204X-1). Its thickness is about 0.8 mm and its degree of foaming is about 20%, the foaming having been brought about by means of expandable microspheres. The foamed cover layer 3 is arranged on top of an upper traction layer 4 consisting of a plain-woven polyester fabric in which the warp threads are multifilaments of 1100 dtex and the weft threads are monofilaments of 0.25 mm diameter. The thickness of the upper traction layer 4 is

about 0.6 mm. The belt also has a second, lower traction layer 5, consisting of a woven polyester fabric of the same construction and thickness as the upper traction layer 4. Sandwiched in between the two traction layers 4 and 5 is an intermediate layer 6 consisting of a foam with identical composition as in the cover layer 3 and having a thickness of about 1.0 mm. The upper traction layer 4 and the intermediate layer 6 are bonded together by means of an upper adhesive layer 7 and the intermediate layer 6 and the lower traction layer 5 are bonded together by means of a lower adhesive layer 8. Both adhesive layers 7 and 8 are of a thermoset polyurethane. The layered compound of upper traction layer 4, adhesive layer 7, intermediate layer 6, adhesive layer 8 and lower traction layer 5 is assembled together by calendering. The cover layer 3 is applied in a last step, again by extrusion coating, and is then embossed to yield the profiled surface 31.

Figures 3-5 illustrate schematically the production of belts of the invention or of layered composites useful as intermediates of the belt of the invention.

Figure 3 shows the production of a thermoplastic elastomeric foam 9 itself in an extruder 10: The granulated or ground, still unfoamed thermoplastic elastomer 11 is mixed in the extruder 10 with optional further additives 12, such as for example dyes, fillers or flame inhibitors. When the blowing agent 13 is easy to meter, when it is solid for example, it can be added together with the thermoplastic elastomer 11 as one of the additives 12. When the blowing agent 13 is gaseous or liquid, it can be introduced into the extruder 10 directly and separately via a feed line 14. The

mixture of all constituents is sufficiently heated and pressurized for the blowing agent to become commixed with the already molten mixture. In some cases, the commixing can be carried out such that the blowing agent is converted into the supercritical state, such as in particular when it is carbon dioxide. The resulting mixture of thermoplastic elastomer 11, additives 12 and blowing agent 13 is foamed up in the extruder 10 and removed from it, for example via a round die, as the foamed thermoplastic elastomer 9. When a slot die is used, the foam 9 can be shaped directly as a foamed thermoplastic elastomer layer.

Figure 4 shows schematically the production by calendering of a layered composite useful as an intermediate in the production of belts of the invention. Here, the layered composite has a lower traction layer 15 and an upper traction layer 16. In between these is calendered an intermediate layer 17, which may be a foamed thermoplastic elastomer layer or a conventional rubber or thermoplastic foamed or unfoamed layer. Initially, the lower traction layer 15 is calendered onto a bottom side 18 of the intermediate layer 17. If an additional adhesive is desired to bond the intermediate layer 17 and the lower traction layer 15 together, then it can be applied to the top side of the lower traction layer by sprinkling in the form of a pulverulent resin 19 or by spraying in the form of a solution in a solvent or by means of a doctor blade before the lower traction layer 15 enters the pair of rolls. An upper traction layer 16 is then calendered onto the top side of the intermediate layer 17. Here too an additional adhesive 21 could optionally be sprinkled or sprayed onto the bottom side of the upper traction layer 16. The thick broken-lined arrow

indicates that the layered composite can subsequently be coated with further layers, such as a foamed thermoplastic elastomer cover layer: In that case the already existing layered composite is fed to the calender from the right instead of the lower traction layer 15 and the further layer to be applied is fed from the left instead of the upper traction layer 16.

Figure 5 shows schematically an extrusion-coating of a layered composite intermediate 22, already comprising any required layers, with a cover layer of a foamed thermoplastic elastomer 23. Initially, the thermoplastic elastomer foam is produced and extruded from an extruder 24 similarly as described above for figure 3. The foam produced may already have the shape of a layer, in which case the extrusion is done with a slot die, or it may yet be of irregular shape, in which case the rolls serve also to impart the foam a layer shape while simultaneously adhering the cover layer to the layered composite intermediate 22.

Example 1: Wear and tear test on a belt of the invention

An endless belt with construction similar to the one shown in figure 2 and as described in the corresponding figure description was used, with the exception that the tested belt did not contain any adhesive layers 7, 8 between the foamed layers 3, 6 and the traction layers 4, 5. The belt was cycled over a test loop consisting of a 130 mm diameter pulley over which the belt was bent by 180°, and of three 12 mm diameter pulleys over each of which the belt was bent by about 160°, the bending over the three pulleys giving the

belt a "w" shape when seen from the side, and the net total bending over the three pulleys being again 180° to close the loop with the 130 mm diameter pulley. The length of the loop was 0.97 m. The belt was cycled over that test loop at a load of 76 N and at a speed of 10 m /sec. After 5 million cycles (i.e. 15 million flexes over the three smaller pulleys) the belt did not show any visible signs of wear or cracks. This test is currently going on at the time of filing of the instant application, until 300 million flexes are achieved or until the belt breaks, whichever occurs earlier.

Example 2: Measurements of several parameters on a comparative belt and on two inventive belts.

Three belts with the construction similar as shown in figure 2 and the corresponding figure description were used. Belt 2 differed from the one of figure 2 in the material of the cover layer 3 and the intermediate layer 6 and in that no adhesive layers 7, 8 were present. Belts 1 and 3 differed from the one of figure 2 only in the material of the cover layer 3 and the intermediate layer 6.

	Belt 1; material of cover layer 3 and intermediate layer 6: unfoamed soft PVC (comparative belt)	Belt 2; material of cover layer 3 and intermediate layer 6: foamed blend of elastomer and TPE-U (Versollan RU 2204) Shore A 55 unfoamed (inventive belt)	Belt 3; material of cover layer 3 and intermediate layer 6: foamed soft polyester-based TPE-U (Laripur 7025), Shore A 70 unfoamed (inventive belt)
k1% relaxed after 43200 cycles at 1.5% extension and 24 hours climatisation at STP	6.7 N/mm	3.5 N/mm	4.6 N/mm
k% static with 3N pre-load, speed of 2% of tested length/min, in the length direction	7.8 N/mm	3.9 N/mm	5.5 N/mm
Ultimate tensile strength with 3N pre-load, speed of 100% of	-	29.1 N/mm	74.5 N/mm

- 23 -

tested length/min			
Same as above measuring elongation, with a joint	-	11.30%	21.30%
Nose bar test, the belt passes around a fixed bar having a radius of 4mm under a tension giving 0.5% extension, at a speed of 1M/s in length direction	after 6 h: failed, a lot of abrasion	after 80 h: no failure	after 80 h: small abrasion
Dynamic coefficient of friction of belt surface against stainless steel after 24 hrs climatisation at STP	0.89	0.81	1.2
Dynamic coefficient of friction of belt backside against stainless steel after 24 hrs climatisation at STP	0.19	0.33	0.39
Static coefficient of friction of belt surface against stainless steel after 24 hrs climatisation at STP	0.56	0.47	0.51
Static coefficient of friction of belt backside against stainless steel after 24 hrs climatisation at STP	0.14	0.19	0.22
Dynamic coefficient of friction of belt surface against pickled steel after 24 hrs climatisation at STP	0.82	0.79	0.97
Dynamic coefficient of friction of belt backside against pickled steel after 24 hrs climatisation at STP	0.18	0.34	0.44
Static coefficient of friction of belt surface against pickled steel after 24 hrs climatisation at STP	0.63	0.58	0.56
Static coefficient of friction of belt backside against pickled steel after 24 hrs climatisation at STP	0.15	0.28	0.33

Claims

1. A belt comprising a foamed layer (1, 3, 6, 17, 23), characterised in that this foamed layer (1, 3, 6, 17, 23) contains a foam of a thermoplastic elastomer, which in the
5 unfoamed state has a Shore A hardness of at the most 85.

2. The belt of claim 1, wherein the Shore A hardness is in the range of 45 to 70, preferably of 50 to 60.

3. The belt of claim 1 or 2, wherein the thermoplastic elastomer is selected from the group consisting of
10 substantially random ethylene/C₃₋₁₂- α -olefin copolymers, optionally blended with a compatible TPA or TPU and/or or a thermoplastic polyolefin; thermoplastic elastomeric block copolymers; blends of thermoplastics and elastomers; alloys of thermoplastics and elastomers; thermoplastic elastomeric
15 ionomers, blends of a TPE-U with another thermoplastic elastomer and blends of a TPE-U with an elastomer.

4. The belt of claim 3, wherein the thermoplastic elastomer is a substantially random ethylene/C₃₋₁₂- α -olefin copolymer blended with a compatible TPU and optionally with a
20 thermoplastic polyolefin; a TPE-U; a blend of a TPE-U with another thermoplastic elastomer; or a blend of a TPE-U with an elastomer.

5. The belt of one of claims 1 to 4, comprising a traction layer (2, 4) comprising a textile fabric or
25 consisting thereof, and wherein the foamed layer is a cover layer (1, 3, 23) arranged on top of the traction layer (2,

4) .

6. The belt of one of claims 1 to 4, comprising an upper traction layer (4, 16) comprising a textile fabric or consisting thereof, and a lower traction layer (5, 15) comprising a textile fabric or consisting thereof, and wherein the foamed layer is a cover layer (3) arranged on top of the upper traction layer (4) and/or an intermediate layer (6, 17) in between the upper traction layer (4, 16) and the lower traction layer (5, 15).

10 7. The belt of claim 5 or 6, wherein the textile fabrics contain fibres of a polyester and the thermoplastic elastomer of the foamed layer(s) (1, 3, 6, 17, 23) is a blend of a substantially random ethylene/C₃₋₁₂- α -olefin copolymer and of a TPA or TPU, optionally further blended with a
15 compatible thermoplastic polyolefin; a TPE-U; a blend of a TPE-U with another thermoplastic elastomer; or a blend of a TPE-U with an elastomer.

8. The belt of claim 7, wherein the C₃₋₁₂- α -olefin is 1-octene.

20 9. The belt according to any one of claims 1 to 8, wherein the foamed layer(s) have a degree of foaming in the range of 5 to 60 percent and preferably in the range of 10 to 40 percent.

10. The belt of anyone of claims 1 to 9, having an
25 overall thickness of 2.5 to 5.5 mm.

11. The belt according to any one of claims 1 to 10,

which is a conveyor belt, a transport belt, a treadmill belt or a printing blanket.

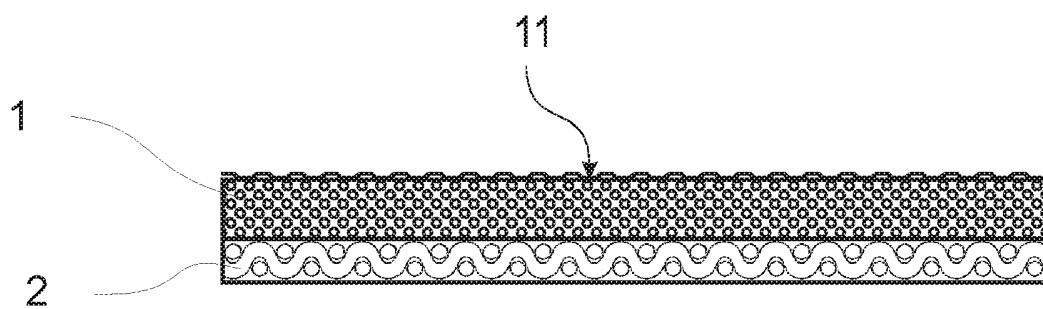
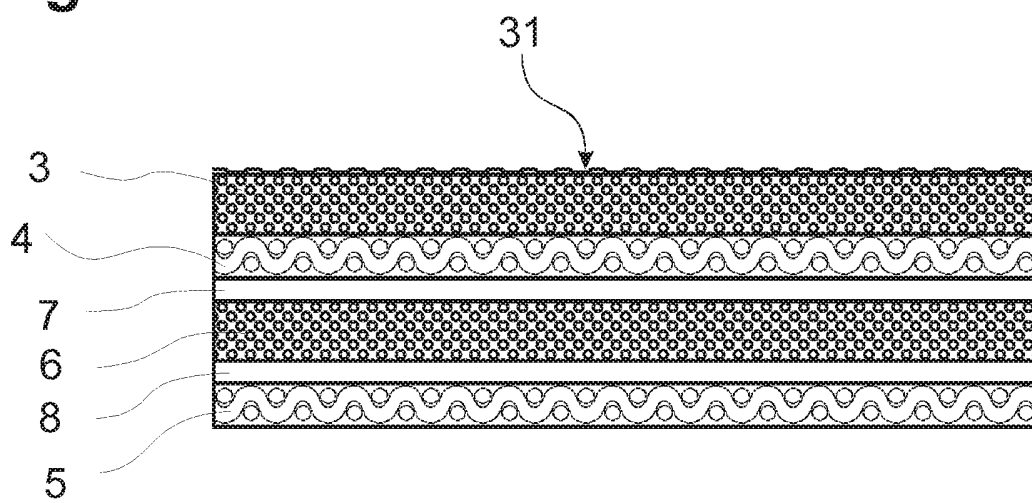
Fig. 1**Fig. 2**

Fig. 3

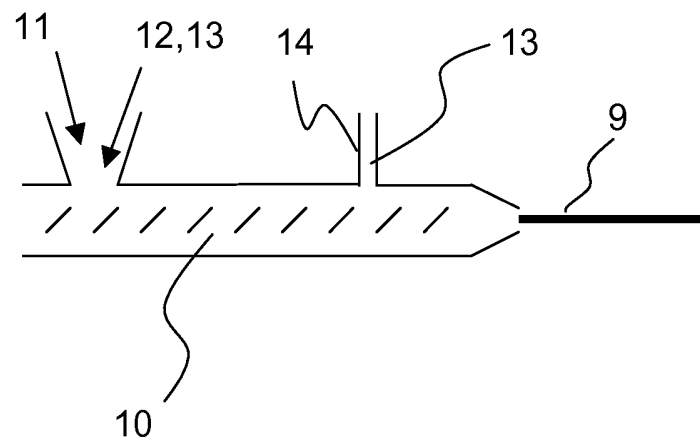


Fig. 4

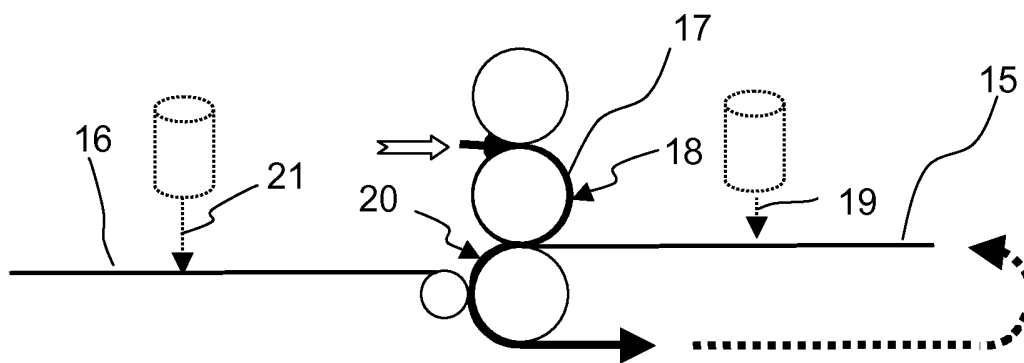
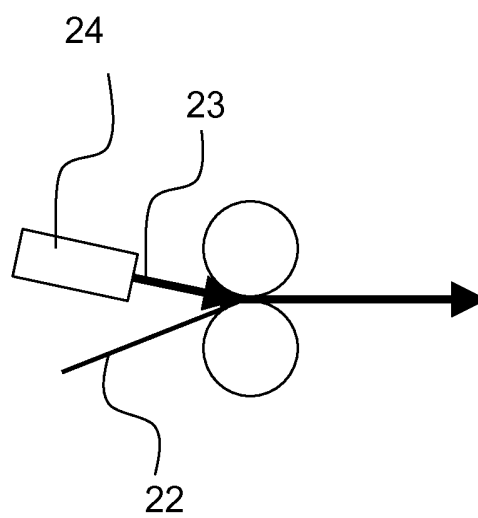


Fig. 5



INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2010/053169

A. CLASSIFICATION OF SUBJECT MATTER

INV. B65G15/34 C08L23/16

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)

B65G C08L

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 practical, 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	WO 02/059194 A (ADVANCED ELASTOMER SYSTEMS [US]; ELLUL MARIA D [US]; SAHNOUNE ABDELHAD) 1 August 2002 (2002-08-01)	1-3
Y	pages 2-4,8; tables 2,3	4-8,11
X	WO 2005/028555 A (ADVANCED ELASTOMER SYSTEMS [US]; ELLUL MARIA [US]; CHENG JOHN [US]) 31 March 2005 (2005-03-31)	1-3
	paragraphs [0003], [0018], [0024], [0034], [0062], [0063]	
A	US 2007/083007 A1 (JACOB SUNNY [US]) 12 April 2007 (2007-04-12)	1-3
	page 2; tables 2,4	
	----- -/--	

☒ 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 document 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

11 June 2010

Date of mailing of the international search report

22/06/2010

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Papatheofrastou, M

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2010/053169

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 02/062682 A (HABASIT AG [CH]; CEDIEL LUIS E [CH]; HONOLD CLAUDIA [CH]; BRODMANN KUR) 15 August 2002 (2002-08-15) pages 6,8; figure 1 -----	5
Y	EP 1 717 169 A (NITTA CORP [JP]) 2 November 2006 (2006-11-02) cited in the application column 4; figures 3,4 -----	4,6-8,11

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2010/053169

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 02059194 A	01-08-2002	AU 2002228797 A1 DE 60108903 D1 DE 60108903 T2 EP 1353995 A2 ES 2233710 T3 JP 4289540 B2 JP 2004521173 T US 2003013813 A1 US 6433090 B1	06-08-2002 17-03-2005 13-04-2006 22-10-2003 16-06-2005 01-07-2009 15-07-2004 16-01-2003 13-08-2002
WO 2005028555 A	31-03-2005	AT 449132 T CN 1852946 A EP 1664189 A1 EP 2143761 A1	15-12-2009 25-10-2006 07-06-2006 13-01-2010
US 2007083007 A1	12-04-2007	EP 1940943 A1 JP 2009511662 T WO 2007044123 A1	09-07-2008 19-03-2009 19-04-2007
WO 02062682 A	15-08-2002	AT 273889 T CA 2435544 A1 DE 50200860 D1 DK 1355839 T3 EP 1355839 A1 ES 2227473 T3 JP 4109993 B2 JP 2004525045 T US 2004065529 A1	15-09-2004 15-08-2002 23-09-2004 13-12-2004 29-10-2003 01-04-2005 02-07-2008 19-08-2004 08-04-2004
EP 1717169 A	02-11-2006	NONE	