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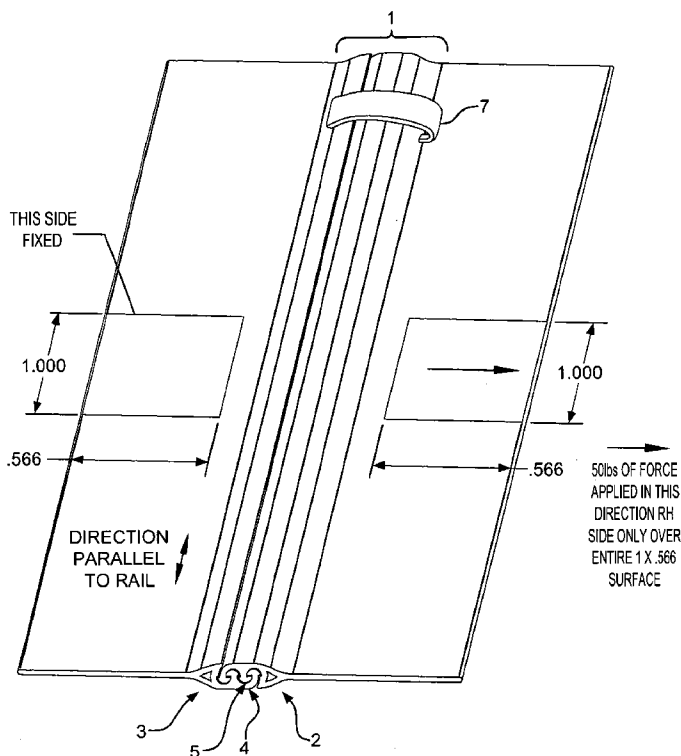


FIG. 1

(57) Abstract: Self-lubricating fastener devices with interlocking rails or interlocking members of a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer are provided. Methods for production of self-lubricating fastener devices and their use in liquid-resistant or liquid-proof articles are also provided. A particular advantage is the ability of the devices to repeatedly reestablish a self-lubricated surface, even after solvent cleaning.

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TITLE OF THE INVENTION

SELF-LUBRICATING FASTENERS

5

CROSS REFERENCE TO RELATED APPLICATION

This application claims priority to provisional application USSN 60/974,977, filed September 25, 2007.

10

BACKGROUND OF THE INVENTION

The invention relates to interlocking rails or teeth comprised of a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer. The self-lubricating interlocking rails or teeth are used in self-lubricating fastener devices, and in particular waterproof fastener devices for garments.

A particular advantage is the elimination of the need to apply a lubricant to the rail at frequent intervals during its lifetime. Some currently commercial devices require relubrication after every ten cycles of the closure. This is inconvenient, time consuming, and can result in contamination of materials in proximity of the device.

Various sliding clasp fasteners with lubricants have been disclosed. For example, a traditional coil type zipper (coupling elements) and a slider adapted to close the coils have been disclosed.

In one embodiment, the coils of the fastener are indented in the surface and mechanically roughened during extrusion or after. A lubricant is dissolved in an appropriate solvent and coated onto the coils. The indented surface is suggested to enhance this coating process.

In another embodiment, a slide fastener is made from a pair of carrier tapes and coupling elements. The coupling elements are either a spiral or continuous coil formed from a filament. A separate cord of an absorbent material soaked in lubricant is positioned adjacent to the coupling elements to reduce friction upon coupling. However, re-application of such lubricants is typically required.

A slide fastener has also been disclosed with polymer interlocking members injection molded directly onto a zipper tape. To aide in the removal of the polymer interlocking members from the die, an organic

mold release agent such as siloxane is added into the polymer extrusion. A decrease in pull force of the zipper with the siloxane present is disclosed. The interlocking members may be rail protrusions, teeth, or lock and key mechanisms.

5 Reclosable household storage bags with sliding fastener closures have also been disclosed. For instance in one such bag, the writing surface is created on the household storage bag via a surface roughening or anti-slip agent. A slip agent is then added to the opposing surface of bag in selected areas, to overcome the anti-slip agent in the
10 opposing surface.

SUMMARY OF THE INVENTION

15 An aspect of the present invention relates to an interlocking rail for self-lubricating fastener devices. The rail comprises a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer.

20 Another aspect of the present invention relates to interlocking members for self-lubricating fastener devices. The interlocking members comprise a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer, or alternatively dispersed throughout a region or portion of the polymer.

25 Another aspect of the present invention relates to a self-lubricating fastener device comprising at least two interlocking rails wherein at least one of the interlocking rails comprises a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer.

30 Another aspect of the present invention relates to a self-lubricating fastener device comprising two interlocking rails wherein one of the interlocking rails comprises a polymer and a roughening agent of a slip system additive dispersed throughout the polymer and the other interlocking rail comprises a polymer and a lubricant of the slip system additive dispersed throughout the polymer.

35 Another aspect of the present invention relates to a self-lubricating fastener device comprising a plurality of interlocking members, said interlocking members comprising a polymer and a slip system additive with a roughening agent and lubricant dispersed throughout the polymer.

Another aspect of the present invention relates to articles such as garments comprising one or more of these self-lubricating fastener devices.

Yet another aspect of the present invention relates to methods for
5 production of interlocking rails or interlocking members and self-lubricating fastener devices.

Yet another aspect of the present invention relates to an interlocking rail fastener device that combines high strength and high flexibility.

10

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a diagram of an exemplary fastener device with self-lubricating interlocking rails of the present invention.

15 Figure 2 is a side view of a different exemplary design of an interlocking rail of the present invention.

Figure 3 is a cross-sectional side view of an interlocking rail portion with a rotation preventer.

Figure 4 is a graph of strength v. flexibility.

20 Figure 5 is a depiction of rotation preventers.

Figures 6A and 6B is a comparison of the prior art to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

25

The present invention provides interlocking rails and interlocking members for use in self-lubricating fastener devices.

By "article" as used herein is meant to include garments, footwear, hardware, bags, protective garments, enclosures such as chemical and
30 biological protective shelters, and the like.

By "self-lubricating" as used herein it is meant that separate application and/or re-application of a lubricant to the fastener device to reduce friction of the fastener device is not required.

By "waterproof" as used herein it is meant any article capable of
35 withstanding a hydrostatic pressure of at least 1.0 psi for a period of at least 1.0 minutes.

By "liquid-proof" as used herein it is meant any article that will not leak or weep liquid when challenged with a test fluid at a pressure of at least 0.07 bar for a duration of at least 3 minutes. The test fluid is at a minimum water, and ideally can be a range of liquid chemicals.

5 By "rotation preventer" as used herein it is meant any means by which the interlocking portions of the rails are prevented from rotational movements relative to each other (upon external force applied relative to the interlocking surfaces) when the fastener is engaged in a "closed" or "locked" configuration. The rotation preventer keeps the interlocking
10 interface from rotating without adding excessive stiffness to the fastener. For example, Figure 1 and 4 depict examples of rotation preventers including, but not limited to, means for preventing rotation, such as protrusions, knobs, thickened areas and other modifications relative to the fastener which prevent rotation.

15 An exemplary fastener device with interlocking rails is depicted in Figure 1.

As shown in Figure 1, the fastener device **1** comprises a first rail **2** and a second rail **3** which are fitted to each other via interlocking design by a metal or plastic slider **7** and a stopper which connects the rails at
20 one end. As also shown in Figure 1, each rail comprises a tongue portion **4** and groove portion **5** for interlocking with the other rail and a flat portion **6** for attachment to an article to be closed with the device.

In one embodiment of the present invention, the self-lubricating fastener device comprises interlocking rails and one or both rails of the
25 fastener device comprise a polymer and a slip system additive dispersed throughout the polymer. The slip system additive comprises a roughening agent which roughens a surface of the rail and a lubricant which lubricates a surface of the rail. Exemplary articles closed with such fastener devices include, but are not limited to, garments, footwear,
30 bags, gloves, head coverings, protective gear, medical transport enclosures, tents, and storage bags. In an alternative embodiment, one of the rails comprises a polymer and a roughening agent of the slip system additive dispersed throughout the polymer while the other rail comprises a polymer and a lubricant of the slip system additive
35 dispersed throughout the polymer.

In yet another embodiment, the self-lubricating fastener device comprises two sets of interlocking members and one or both sets of

interlocking members of the fastener device comprise a polymer and a slip system additive dispersed throughout the polymer.

In an alternative embodiment, two sets of interlocking members are used to create a seal. One set of interlocking members comprises a
5 polymer and a roughening agent of the slip system additive dispersed throughout the polymer while the other set of interlocking members comprises a polymer and a lubricant of the slip system additive dispersed throughout the polymer.

Exemplary polymers for use in these rails and interlocking
10 members of the present invention include, but are not limited to, polyurethanes, thermoplastic polymers, silicones, thermoplastic elastomers or rubbers or the like, polyethylenes, polyesters, polypropylenes, polyvinyl chlorides, fluoropolymers, and blends thereof.

The slip system additive dispersed throughout the polymer
15 comprises a roughening agent which roughens a surface of the rail or interlocking members and a lubricant which lubricates a surface of the rail or interlocking members. In one embodiment, the slip system additive comprises at least one roughening agent with at least one lubricant.

The roughening agent of the slip system additive roughens the
20 surface of the rail or interlocking members to increase roughness and reduce the contact points between the surfaces allowing the surfaces to move past each other with less friction, preferably without changing the bulk properties of the polymer. Exemplary roughening agents useful in
25 the slip system additive comprise inorganic materials including, but not limited to silica, aluminums, silicates, diatomaceous earth, or talc. It is to be further understood that roughening agents may be chosen from inorganic or organic materials for the applications taught herein.

The lubricant of the slip system additive reduces friction during
30 closing and opening of a fastener device comprising the rails or sets of interlocking members. Lubricants useful in the present invention are dissolvable in either a polar or non-polar solvent such as alcohol, preferably ethanol, isopropyl alcohol, hexane, methylene chloride, or methyl ethyl ketone, or acetone. Such lubricants tend to appear or
35 reappear at the surface of the polymer and reduce surface friction. Further, preferred lubricants for use in the present invention do not interfere with adherence of the fastener device with a hot melt adhesive.

Exemplary lubricants useful in the slip system additive include, but are not limited to, oleamides, stearamides, ethylene bis-oleamides, ethylene bis-stearamides, siloxanes, fluorinated polymers and erucamides, stearyl alcohol, stearic acid, stearates, and metal salts of stearic acid such as
5 magnesium and calcium, silicones, polytetrafluoroethylene, and the like.

The slip system additive is dispersed in the polymer at a rate of 0.1 to 20 weight percentage, more preferably at a rate of 2 to 5 weight percentage.

By "dispersed throughout the polymer" as used herein it is meant
10 that the slip additive agent or a component of the slip additive agent is diffused evenly or unevenly throughout the polymer so that at least a portion of the produced rail or interlocking members contain both polymer and the slip additive agent or a component thereof. Dispersion of the slip additive agent throughout the polymer eliminates the need to
15 coat the polymer and/or re-apply lubricant to the fastener device after use. It is preferred that the slip additive agent is not simply a topical coating or application as those used for mold release. Conventionally, it is an unwanted effect to have such slip additive present in or on final products as they may contribute undesirable qualities.

20 In one embodiment, the slip system additive is evenly distributed throughout the polymer and the resulting interlocking rails or interlocking members. For this embodiment, the interlocking rails or interlocking members may be produced by blending of the polymer and slip system additive prior to or during extrusion of the polymer.

25 Alternatively, the slip system additive may be dispersed throughout a portion of the polymer and the resulting interlocking rails or interlocking members. For example, a blend of polymer and slip system additive can be co-extruded with polymer without slip system additive so that, for example, the tongue and groove portion of an interlocking rail
30 comprises polymer and slip system additive while the flat tape portion of the interlocking rail comprises polymer without slip system additive.

In these embodiments, both the lubricant and the roughening agent are included in the portion of the polymer containing the slip system additive.

35 In an alternative embodiment of the present invention, the self-lubricating fastener device comprises a first interlocking rail or first set of interlocking members comprising a polymer and the roughening agent of

the slip system additive dispersed throughout the polymer of the first rail or first set of interlocking members and a second interlocking rail or second set of interlocking members comprising a polymer and a lubricant of the slip system additive dispersed throughout the polymer of the
5 second rail or second set of interlocking members.

Also provided in the present invention are methods for production of self-lubricating fastener devices.

In one embodiment, the method comprises combining or blending a polymer with a slip system additive. The resulting combination or
10 blend is then extruded, injected molded, RTV, spin cast, SLA, SLS, three-dimensional print, CNC or any other suited method for molding the interlocking pieces into interlocking rails or interlocking members of polymer with slip system additive dispersed throughout. These interlocking pieces are then assembled into a self-lubricating fastener
15 device.

In another embodiment, the method comprises combining or blending a polymer with a slip system additive. The resulting combination or blend is then extruded along with a polymer into interlocking rails or interlocking members, a portion of which comprises
20 polymer with slip system additive dispersed throughout. These interlocking pieces are then assembled into a self-lubricating fastener device.

In another embodiment, the method comprises combining or blending a polymer with a roughening agent of a slip system additive.
25 The resulting combination or blend is then extruded into a first interlocking rail or first set of interlocking members comprising polymer with roughening agent dispersed throughout. A polymer is also combined or blended with a lubricant of a slip system additive and the resulting combination or blend is extruded into a second interlocking rail
30 or second set of interlocking members comprising polymer with lubricant dispersed throughout. These first and second rails or first and second sets of interlocking members are then assembled into a self-lubricating fastener device.

The self-lubricating fastener devices of the present invention are
35 liquid-resistant, more preferably liquid-proof. Further, these self-lubricating fastener devices of the present invention exhibit improved strength as well as increased strength to mass ratio, making them

stronger and lighter at the same time, as well as increased flexibility, as compared to waterproof fastener samples prepared using a commercially available thermoplastic polyurethane (Bayer Texin 990R) and common profile extrusion processes. In order to provide a device that provides
5 high strength and flexibility, it is necessary to provide means to prevent rotation of the interlocking elements relative to themselves during cross-wise tensile loading. In one embodiment, geometrical features are altered to prevent such rotation.

Figure 2 shows an aspect of the fastener device **1** which
10 comprises a first rail **2** and a second rail **3** which are able to be fitted to each other via interlocking design by a slider device used to connect or separate the interlocking surfaces. As also shown in Figure 2, each rail comprises a tongue portion **4** and groove portion **5** for interlocking with the other rail and a flat portion **6** for attachment to an article to be closed
15 with the device. The rotation preventer **30** is also shown as protrusions or thickened areas which resist movement of the tongue portions relative to the groove portions during stress force applications.

Figure 3 shows a fastener device **1** which comprises a first rail **2** and a second rail **3** which are fitted to each other via interlocking design
20 to connect the rails. The rotation preventer **30** is also shown as protrusions or thickened areas which resist movement of the tongue portions relative to the groove portions during stress force applications.

The necessity for this rotation preventer is depicted in Figures 4 and 5. Figure 5 has four images numbered 5A through 5B. Figure 5A
25 depicts a cross-section of a rail at the beginning of a cross-pull test. Figure 5B is the same depiction, but with overlaid lines A and B. Line A represents the general shape of a portion of the interlock. Line B represents the orientation of another area of the interlock. Figure 5C is a depiction of a rail cross-section just prior to rail separation. Figure 5D is
30 the same depiction as Figure 5C, but with lines A and B again added. Note that line A is considerably straighter in Figure 5D than it is in Figure 5B. Also note that line B has an orientation in Figure 5D that is nearly perpendicular to its orientation in Figure 5B. For both lines A and B, the changes in shape and orientation are caused by a rotation of
35 certain areas of the interlock. If structural elements can be added that prevent this rotation without an undue loss of in-plane flexural flexibility, the cross-pull strength of the device can be increased while retaining

satisfactory flexural flexibility. Alternatively, these elements can be added, and the entire cross-section can be scaled down, so as to create a device with similar strength but improved flexural flexibility.

Figure 6A shows a prior art rail profile. Figure 6B shows the improved rail design of the present invention illustrating that reduction of tooth rotation is accomplished by elimination of unnecessary undercut sizing **100** on reduction of the overhang **200** of the undercut on the tongue portion in conjunction with an increased reinforced area **300**. This allows prevention of head rotation relative to the neck portion of the tongue.

For example, a self-lubricating fastener device of the present invention comprising interlocked rails is able to withstand up to 50 pounds of force applied in the direction depicted in Figure 1 as measured per ASTM D2061-07. This is known as cross-pull strength measurement. Flexibility, as assessed via a three-point bending method, was also increased. For this assessment, a TA Instruments RSA3 Dynamic Mechanical Analyzer (DMA) with standard 25 mm span three-point bending fixture was used. Samples were tested as paired rails with a preload of 1.0 g, a max deflection of 1.0 mm and a rate of 0.25 mm/seconds. The slope of the load-deflection curve between 0.3 and 1.0 mm was used in to calculate flexibility. The flexibility is defined as the inverse of the product of the elastic modulus (E) and the second moment of inertia (I), designated $(EI)^{-1}$. For three-point bending, $(EI)^{-1} = 48y/PL^3$, where y = deflection, P = load, and L = span = 25 mm.

An interlocking rail of the present application comprises a polymer and a slip system additive dispersed throughout the polymer. The rail has been found to have favorable strength to mass ratios of greater than 2.99 Nm/g. Further, the mass per unit length of the rail has been found to be less than 80 grams per meter as exemplified in the examples.

Surface roughness was performed using a Zygo New View 5032 optical profilometer, with a 10X objective. Samples were mounted onto a glass slide using carbon tape and placed on a leveled stage for roughness analysis. Three 1.0 mm scans per sample were measured. All data is recorded in microns. The data is fitted to a straight baseline and unfiltered. The reported data is for the direction parallel to the interlocking rail. The average roughness (Ra) reported is the average distance between the surface and the meanline looking at all of the

points along the profile. It has been found possible to achieve surface roughness parallel to the rail of greater than 0.3 micrometers Ra.

Thus, the self-lubricating fastener devices of the present invention are particularly useful in production of water-resistant or waterproof articles requiring fastener devices such as garments and bags. The self-lubricating fastener devices of the present invention are useful in joining gloves and socks to chemical and/or biological protective gear as well as in liquid-resistant or liquid-proof garments.

The following non-limiting examples are provided to further illustrate the present invention.

Examples

Example 1: Comparative Waterproof Fastener

A waterproof fastener sample (CH1351-37-15) was prepared using commercially available thermoplastic polyurethane (Bayer Texin 990R) and common profile extrusion processes. The profile of the resulting rail consisted of a tail section for garment attachment, a transition section, and a twin-mushroom style interlock section (see Figure 2). The opposing rail sections were identical. Following extrusion, the rails were sprayed with a lubricant by 303 Aerospace Lubricant made by 303 Products Palo Cedro, CA then assembled together, and tested. The mass per unit length of the sample was 52 grams/meter. The mean cross-pull strength was 89 Newtons (N). The flexural flexibility was 1421 Newtons/meter ($N^{-1}m^{-2}$). The strength-mass ratio was 1.70 (Newtons x meters)/gram or (Nm/g). The strength-flexibility product was 126943 m^{-2} . The average surface roughness (Ra) in the extruded direction was 0.24 μm .

Example 2: Comparative Waterproof Fastener

A waterproof fastener sample (CH1351-37-16) was prepared similarly to that of Comparative Example #1, except that the extrusion speed was adjusted so that the mass per unit length of this sample was 68 grams/meter. The mean cross-pull strength was 100 N. The flexural flexibility was 1388 $N^{-1}m^{-2}$. The strength-mass ratio was 1.46 Nm/g. The strength-flexibility product was 138337 m^{-2} . The average surface

roughness (Ra) in the extruded direction was 0.28 μm .

Example 3: Waterproof Fastener

A waterproof fastener sample (CH1351-37-1) was prepared from
5 Estane 58219 resin (available from Lubrizol, Wickliffe, Ohio) blended
with Estane Slip System X-4036 using common profile extrusion
processes as described in Comparative Example 1. Like Comparative
Example 1, the rail profile consisted of a tail section for garment
attachment and a transition section. However, the rail comprised a twin-
10 wave style interlock section (see Figure 3). No additional lubricant was
applied to the sample following extrusion. The mass per unit length of
the sample was 71 grams/meter. The mean cross-pull strength was 212
N. The flexural flexibility was $1186 \text{ N}^{-1}\text{m}^{-2}$. The strength-mass ratio was
2.99 Nm/g. The strength-flexibility product was 251000 m^{-2} . The
15 average surface roughness (Ra) in the extruded direction was 0.40 μm .

Example 4: Waterproof Fastener

A waterproof fastener sample (CH1351-37-2) was prepared
similarly to that in Example 1, except that the extrusion speed was
20 adjusted so that the mass per unit length of the sample was 47 g/m. The
mean cross-pull strength was 143 N. The flexural flexibility was
 $1800/\text{N}^{-1}\text{m}^{-2}$. The strength-mass ratio was 3.03 Nm/g. The strength-
flexibility product was 260000 m^{-2} . The average surface roughness (Ra)
in the extruded direction was 0.40 μm .

25

Example 5: Waterproof Fastener

A waterproof fastener sample (CH1351-37-5) was prepared
similarly to that in Example 1, except that the extrusion speed was
adjusted so that the mass per unit length of the sample was 34 g/m. The
30 mean cross-pull strength was 103 N. The flexural flexibility was $4347 \text{ N}^{-1}\text{m}^{-2}$.
The strength-mass ratio was 3.01 Nm/g. The strength-flexibility
product was 446000 m^{-2} . The average surface roughness (Ra) in the
extruded direction was 0.75 μm .

Example 6: Waterproof Fastener

A waterproof fastener sample (CH1351-37-3) was prepared
similarly to that in Example 1, except that the extrusion reduction ratio

was adjusted to give a mass per unit length of the sample of 18 g/m.

The mean cross-pull strength was 77 N. The flexural flexibility was 8245 $\text{N}^{-1}\text{m}^{-2}$. The strength-mass ratio was 4.21 Nm/g. The strength-flexibility product was 638000 m^{-2} . The average surface roughness (Ra) in the
5 extruded direction was 0.59 μm .

Example 7: Waterproof Fastener

A sample ZIPLOC® “Big Bags” fastener was evaluated for strength and flexibility. The samples were reassembled so as to be
10 suitable for cross-pull testing. The mean cross-pull strength was 87 N. The flexural flexibility was 3120 $\text{N}^{-1}\text{m}^{-2}$. The strength-flexibility product was 271000 m^{-2} . The sample had a glossy appearance, indicating a very low surface roughness.

Example 8: Waterproof Fastener

A sample YKK rail fastener (Part No. 5PVH) was evaluated for strength and flexibility. The samples were reassembled so as to be
15 suitable for cross-pull testing. The mean cross-pull strength was 252 N. The flexural flexibility was 515 $\text{N}^{-1}\text{m}^{-2}$. The strength-flexibility product was 129780 m^{-2} . The sample had a glossy appearance, indicating a very low surface roughness.
20

The relative strength and flexibility of these Examples 1-8 are depicted in Figure 4. It can be seen that the invention provides an
25 improvement in combined strength and flexibility represented by the area to the right of the solid line. It is to be noted that gross calculations reported in Examples 1-8 were based upon measured values prior to rounding to the reported nearest whole number.

Example 9: Test Method

Coefficient of Friction Measurement:

Coefficient of friction measurements (COF) were made using test
30 method ASTM D1894-06 with a sled speed of 90 inches per minute and a sled load of 600 gram. The sled base measured 2.5 inches by 2.5
35 inches. The coefficient of friction was measured ten times per test specimen and the averages reported in the result table.

Coefficient of Friction Measurements after Abrasion:

Coefficient of friction after abrasion is an important indicator of the longevity of the effect of added lubricants to a polymer extrusion. Thus, the flat samples prepared for the coefficient of friction measurements were also subjected to Martindale Abrasion Testing using a modified ASTM D4966-98 test method. The modification involved using "0" Emery Cloth as the abradent and doing 100 cycles (1600 movements) with a 12kPaA load. After each test specimen was abraded according to this protocol, the coefficient of friction was again measured using the COF test method. The after abrasion test results are also shown in the results table.

Example 10: Lubricant Effect

The effect of lubricant on the coefficient to friction (COF) of flat test specimens the polyurethane material used to make up the rails was determined experimentally. Flat sheet extrusions of a mixture of Estane 58219 and Estane X4036 polyurethane were prepared using standard extrusion conditions as recommended by the resin manufacturer. This master-batch composition was the basis for all subsequent experiments with various lubricant types and levels added. These samples also served as the non-lubricated baseline.

To determine the effect of both (1) an erucamide blend lubricant (ECM Plastics, Inc., Worcester, Massachusetts, part No. CPU310), and (2) with PTFE micropowder, additional batches of Estane 58219/ Estane X4036 were compounded but this time with the lubricant included. These compounded, lubricant-containing batches were then extruded into flat sheets using similar conditions as those used for the non-lubricated control samples.

Different concentrations of the erucamide blend lubricant and of the PTFE micropowder were evaluated. The initial test specimens were prepared using 0%, 3%, and 6% by weight of erucamide blend lubricant in the base polyurethane polymer. After these data were determined, new set of polyurethane extrusions were prepared with the same levels of lubricant but with the addition of 0%, 3%, and 6% PTFE micropowder (available from Shamrock as T-815 PTFE micropowder) added into the compounded mix used to produce the polymer extrusion.

Table 1 - Coefficient of Friction Results

	PTFE Percentage	PTFE Percentage	PTFE Percentage	PTFE Percentage	PTFE Percentage	PTFE Percentage
	0% weight	0% weight	3% weight	3% weight	6% weight	6% weight
	No Abrasion	100 Abrasion Cycles	No Abrasion	100 Abrasion Cycles	No Abrasion	100 Abrasion Cycles
Sample A: 0% weight CPU310 lubricant	>5 lb	--	2.17lb	2.05 lb	2.53 lb	2.10 lb
Sample B: 3% weight CPU310 lubricant	1.81 lb	2.6 lb	2.05 lb	2.47 lb	2.45 lb	2.27 lb
Sample C: 6% weight CPU310 lubricant	1.36 lb	2.11 lb	2.46 lb	2.32 lb	2.66 lb	1.23 lb

5 Based on Table 1 above, several lubrication conclusions can be reached. The addition of the lubricant lowers the COF of the initial samples with no abrasion. However after abrasion, the COF increases. This increase of COF after abrasion suggests that the lubricant effectiveness is decreasing. In contrast, when the PTFE micropowder is additionally added to a lubricated sample, the COF after abrasion does not increase.

Example 11:

15 The effect on rail zipper pull force was determined based on Sample B in Table 1. The zipper pull force was measured using a modified ASTM D1876, where the pull rate was 12 inches per second over a range of 14 inches. The average of the pull force readings was reported. Rails with the same composition as Sample B with no PTFE micropowder were compared to rails with the same composition as

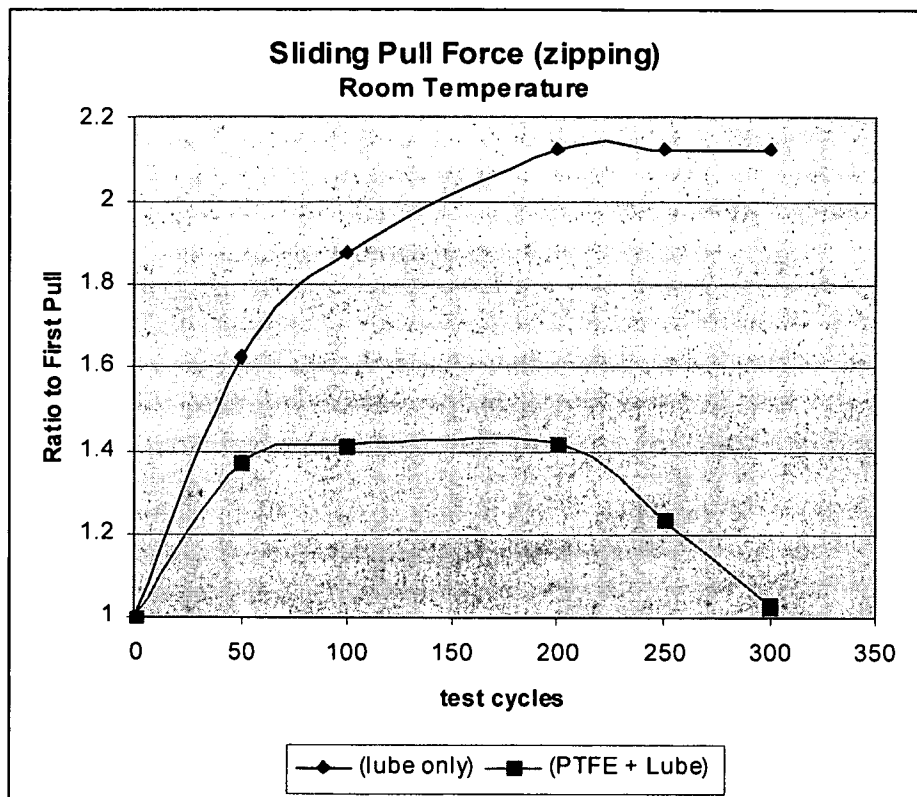
20 Sample B with 3% PTFE micropowder added. In order to normalize these data, the results reported are the ratio of pull force for each pull divided by the initial pull force. These results are shown in Table 2 below.

25 These results show that without the PTFE micropowder, the pull force increases with the number of test cycle pulls until it plateaus off at

about 200 cycles until the end of the test at 300 cycles. The plateau value shows the pull force in the absence of the PTFE micropowder has more than doubled by about 200 cycles. In contrast, the pull force with the PTFE micropowder present increases slightly up to about 50 cycles and then levels off to about 200 cycles, after which, the pull force begins to decrease. By the end of this 300 cycle test, the final pull force with the PTFE micropowder is essentially the same at the initial pull force.

10

Table 2



CLAIMS

WHAT IS CLAIMED IS:

- 5 1. A self-lubricating fastener device comprising a polymer and a slip system additive dispersed throughout said polymer.
2. The self-lubricating fastener device of claim 1 comprising an interlocking rail produced from the polymer and slip system additive.
- 10 3. The self-lubricating fastener device of claim 1 comprising two interlocking rails produced from the polymer and slip system additive.
- 15 4. The self-lubricating fastener device of claim 1 comprising an interlocking set of interlocking members produced from the polymer and slip system additive.
- 20 5. The self-lubricating fastener device of claim 1 comprising two interlocking sets of interlocking members produced from the polymer and slip system additive.
- 25 6. The self-lubricating fastener device of claim 1 wherein the polymer comprises a polyurethane.
- 30 7. The self-lubricating fastener device of claim 1 wherein the slip system additive comprises a roughening agent which roughens at least one surface of the polymer and a lubricant which lubricates at least one surface of the polymer.
- 35 8. The self-lubricating fastener device of claim 1 wherein the polymer comprises a thermoplastic polymer with a glass transition temperature (T_g) of at least -49 degrees Fahrenheit.
9. The self-lubricating fastener device of claim 7 wherein the roughening agent is an inorganic material.

10. The self-lubricating fastener device of claim 7 wherein the lubricant is dissolvable in solvent.
- 5 11. The self-lubricating fastener device of claim 10 wherein the solvent is an alcohol or acetone.
12. The self-lubricating fastener device of claim 7 wherein the lubricant does not interfere with adherence of the fastener device with a hot melt adhesive.
- 10 13. The self-lubricating fastener device of claim 1 wherein the slip system additive is dispersed throughout the polymer at a percentage of 0.1 to 10 percent by weight.
- 15 14. The self-lubricating fastener device of claim 1 wherein the slip system additive is dispersed throughout the polymer at a percentage of 10 to 20 percent by weight.
- 20 15. The self-lubricating fastener device of claim 1 wherein the slip system additive is blended with the resin at a percentage of 2 to 5 percent by weight.
- 25 16. The self-lubricating fastener device of claim 1 wherein the slip system additive is evenly distributed throughout the polymer of the fastener device.
- 30 17. The self-lubricating fastener device of claim 1 wherein the slip system additive is unevenly distributed throughout the polymer of the fastener device.
- 35 18. The fastener device of claim 1 wherein the polymer and slip system additive are extruded into an interlocking rail or a set of interlocking members of the fastener device.
19. The fastener device of claim 1 which is liquid-resistant.
20. The fastener device of claim 1 which is liquid-proof.

21. An article comprising the fastener device of claim 1 wherein the article is a garment.
- 5 22. An interlocking rail for a fastener device, said rail comprising a polymer and a slip system additive dispersed throughout the polymer.
- 10 23. An interlocking rail for a fastener device comprising a surface, said surface having a surface roughness parallel to the rail of greater than 0.3 micrometers Ra.
- 15 24. An interlocking rail for a fastener device comprising a surface, said surface having a surface roughness parallel to the rail of greater than 0.5 micrometers Ra.
- 20 25. The interlocking rail of claim 22 wherein the polymer comprises a polyurethane.
- 20 26. The interlocking rail of claim 22 comprising a surface having a surface roughness in the direction parallel to the rail of greater than 0.3 micrometers Ra.
- 25 27. The interlocking rail of claim 22 comprising a surface having a surface roughness in the direction parallel to the rail of greater than 0.5 micrometers Ra.
- 30 28. The interlocking rail of claim 22 wherein the slip system additive comprises a roughening agent which roughens a surface of the rail and a lubricant which lubricates a surface of the rail.
29. The interlocking rail of claim 28 wherein the roughening agent is an inorganic material.
- 35 30. The interlocking rail of claim 1 wherein the device further comprises a rotation preventer.

31. The interlocking rail of claim 30 wherein the solvent is an alcohol or acetone.
- 5 32. The interlocking rail of claim 30 wherein the lubricant does not interfere with adherence of the interlocking rail with a hot melt adhesive.
- 10 33. The interlocking rail of claim 22 wherein the slip system additive is dispersed in the polymer at a percentage of 0.1 to 10 percent by weight.
- 15 34. The interlocking rail of claim 22 wherein the slip system additive is dispersed in the polymer at a percentage of 2 to 5 percent by weight.
- 20 35. The interlocking rail of claim 22 wherein the slip system additive is evenly distributed throughout the polymer of the interlocking rail.
36. The interlocking rail of claim 22 wherein the slip system additive is unevenly distributed throughout the polymer of the interlocking rail.
37. The interlocking rail of claim 22 produced by an extrusion process.
- 25 38. The interlocking rail of claim 37 wherein the polymer and slip system additive are coextruded with polymer without slip system additive so that a tongue and groove portion of the interlocking rail comprises polymer and slip system additive and a flat tape portion of the interlocking rail comprises polymer without slip system additive.
- 30 39. The interlocking rail of claim 22 having a paired flexibility greater than $1400 \text{ N}^{-1}\text{m}^{-2}$ and wherein the cross-pull strength in Newtons is greater than 120 minus (0.00814 times the flexibility) (as determined by ASTM D2061-07).
- 35 40. The interlocking rail of claim 22 having a paired flexibility less than $1400 \text{ N}^{-1}\text{m}^{-2}$ and wherein the cross-pull strength in Newtons is

greater than 423 minus 0.216 multiplied by the flexibility as determined by ASTM D2061-07.

- 5 41. The interlocking rail of claim 22 comprising at least one feature that prevents rotation of the interlocking elements.
- 10 42. A self-lubricating fastener device comprising at least two rails wherein one rail comprises a polymer and a slip system additive dispersed throughout said polymer.
- 15 43. A self-lubricating fastener device comprising at least two rails wherein one rail comprises a polymer and a roughening agent dispersed throughout said polymer.
- 20 44. A fastener device comprising:
(a) a first interlocking rail with a tongue portion, a groove portion and a tape portion; and
(b) a second interlocking rail with a tongue portion, a groove portion and a tape portion;
wherein the tongue portion of the first interlocking rail interlocks with the groove portion of the second interlocking rail and the tongue portion of the second interlocking rail interlocks with the groove portion of the first interlocking rail; and
wherein at least one of the tongue portions and groove portions of one of the interlocking rails comprises a polymer and a slip system additive dispersed throughout the polymer.
- 25 45. A method of forming a self-lubricating fastener comprising the steps of:
30 (a) combining or blending a polymer with a slip system additive;
(b) extruding the resulting combination or blend into interlocking rails or interlocking members of polymer with slip system additive dispersed throughout; and
35 (c) assembling the interlocking rails or interlocking members into a self-lubricating fastener.

46. A method of forming a self-lubricating fastener comprising the steps of:
- (a) combining or blending a polymer with a slip system additive;
 - (b) extruding the resulting combination or blend and a polymer with no additional slip system additive into interlocking rails or interlocking members; and
 - (c) assembling the interlocking rails or interlocking members into a self-lubricating fastener.
47. A method of forming a self-lubricating fastener comprising the steps of:
- (a) combining or blending a polymer with a roughening agent of a slip system additive;
 - (b) extruding the resulting combination or blend of step (a) into a first interlocking rail or first set of interlocking members comprising polymer with roughening agent dispersed throughout;
 - (c) combining or blending a polymer with a lubricant of a slip system additive;
 - (d) extruding the resulting combination or blend of step (c) into a second interlocking rail or second set of interlocking members comprising polymer with lubricant dispersed throughout; and
 - (e) assembling the first and second rails or first and second sets of interlocking members into a self-lubricating fastener.
48. A device comprising any of the structural features described herein and shown in the drawings forming part of the invention disclosure.
49. An interlocking rail for a fastener device, said rail comprising a polymer and a slip system additive dispersed throughout the polymer and having a strength to mass ratio of greater than 2.99 Nm/g.
50. The interlocking rail of claim 49 wherein the rail has a mass per unit length of less than 80 grams per meter.

51. The interlocking rail of claim 49 wherein the rail has a mass per unit length of less than 40 grams per meter.
 52. The interlocking rail of claim 49 wherein the rail has a mass per unit length of less than 20 grams per meter.
- 5

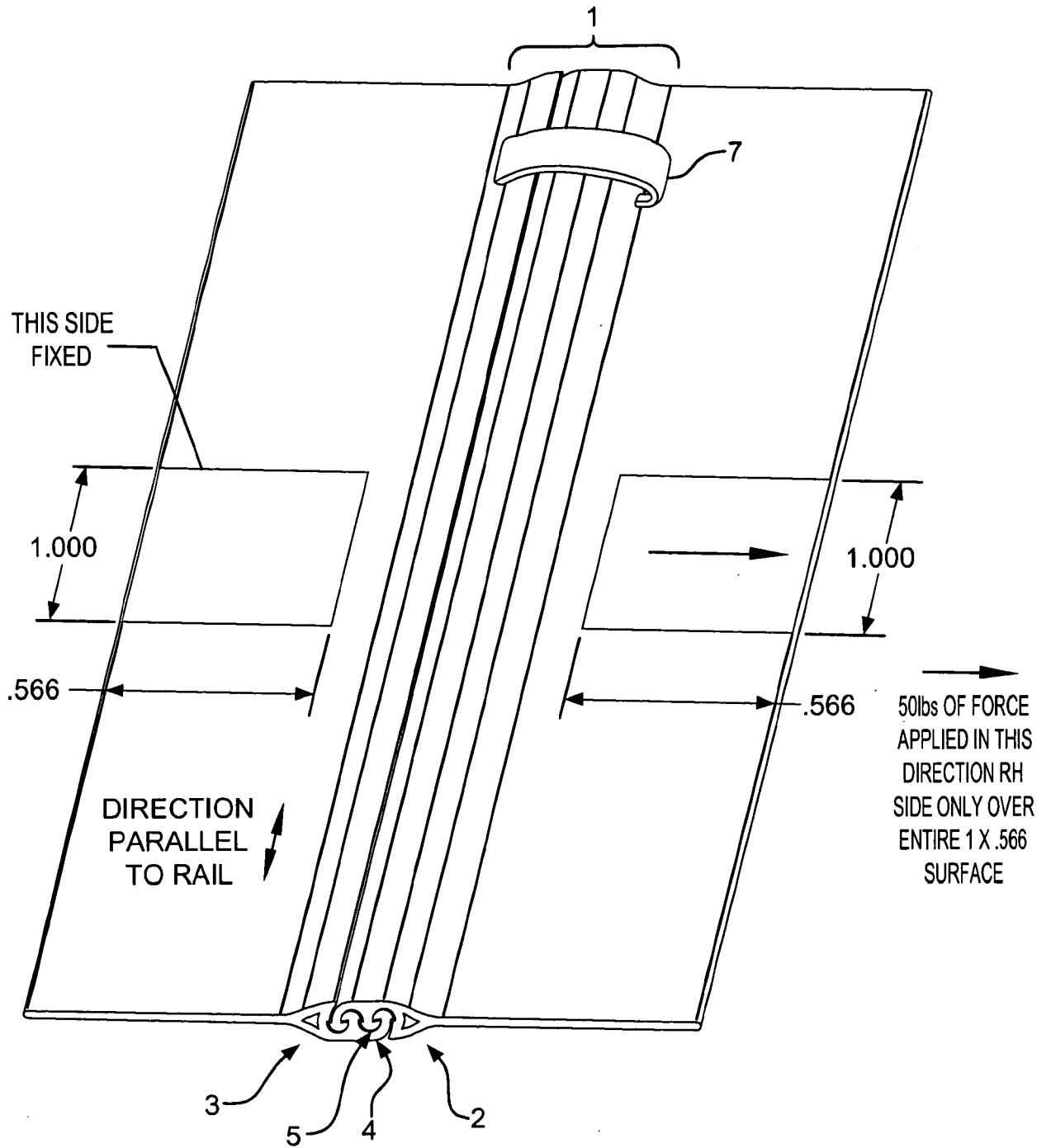


FIG. 1

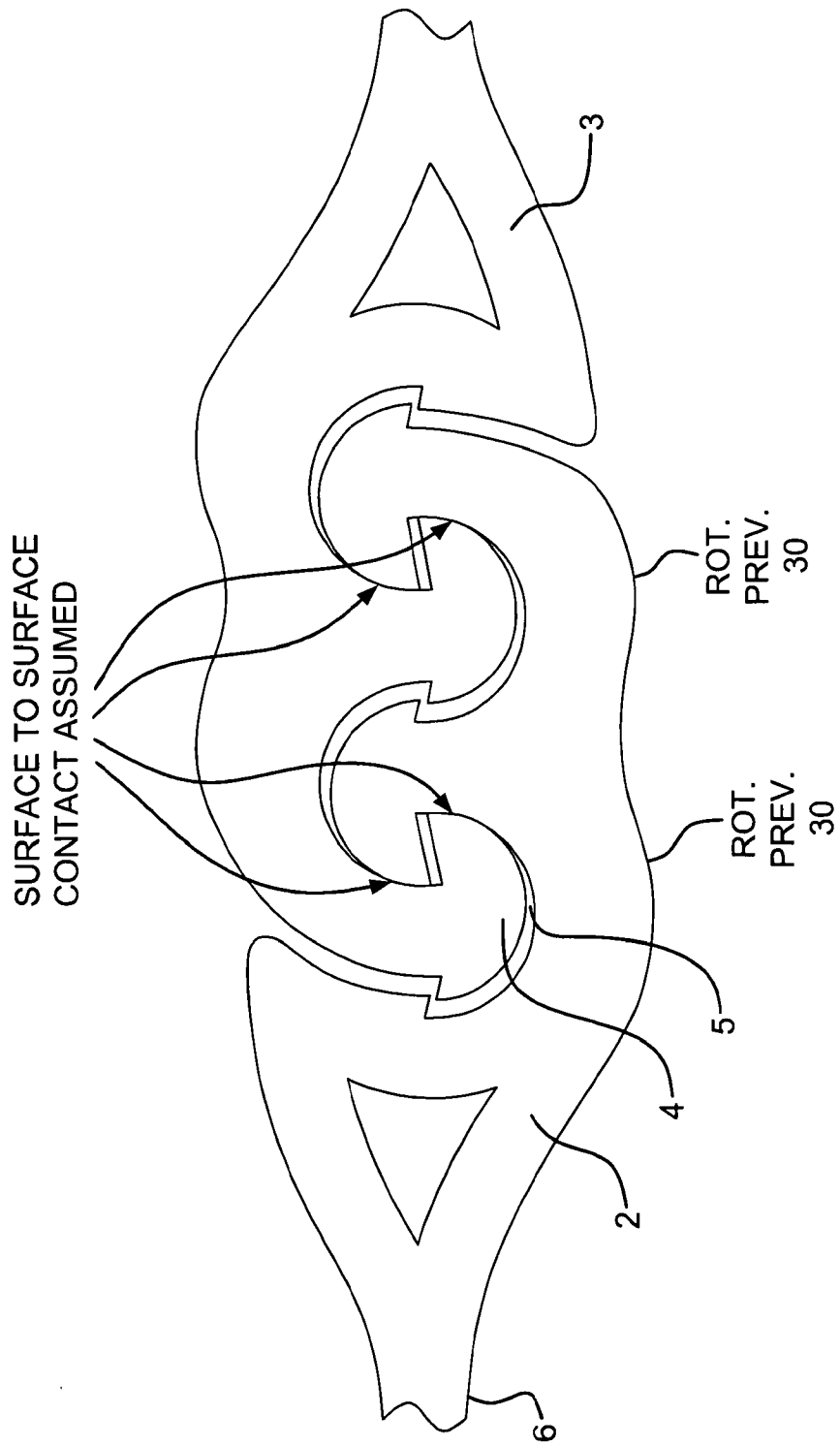


FIG. 2

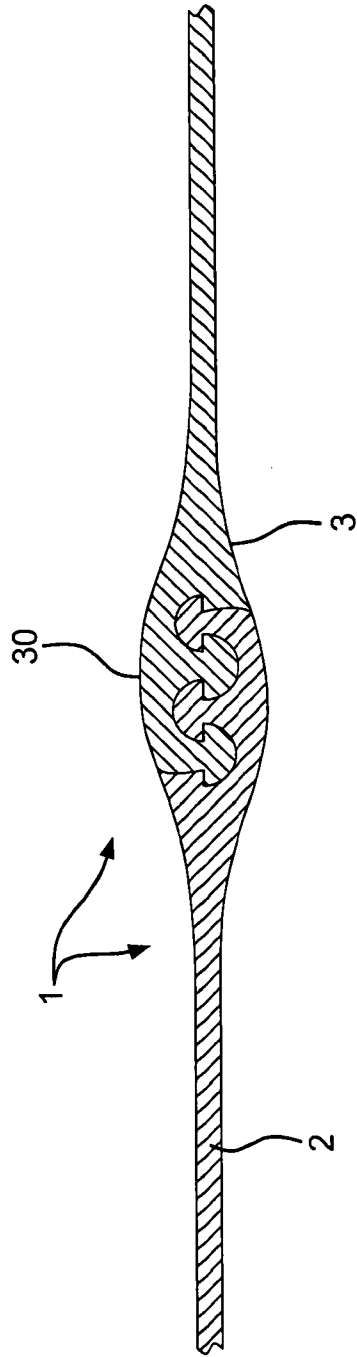


FIG. 3

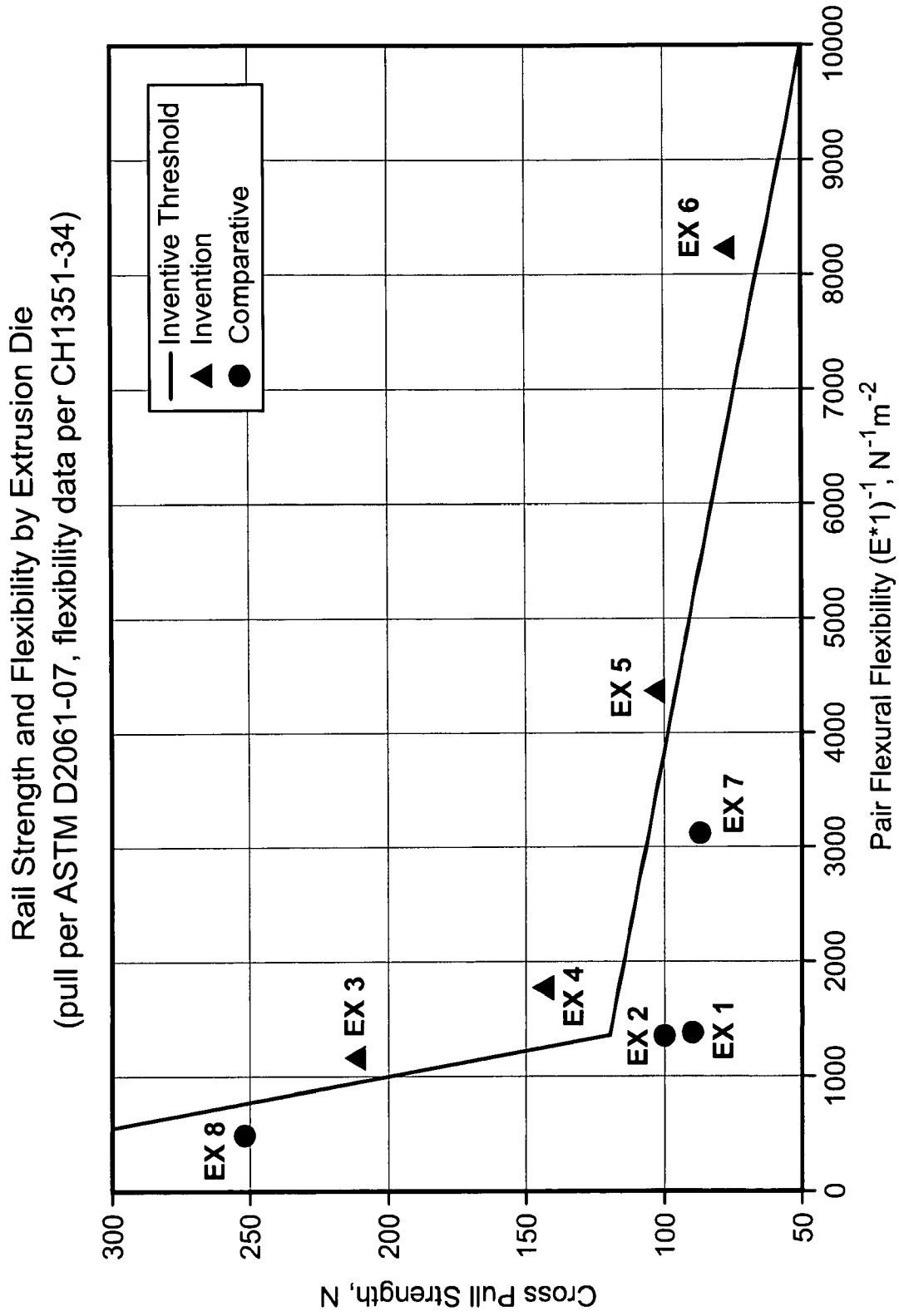


FIG. 4

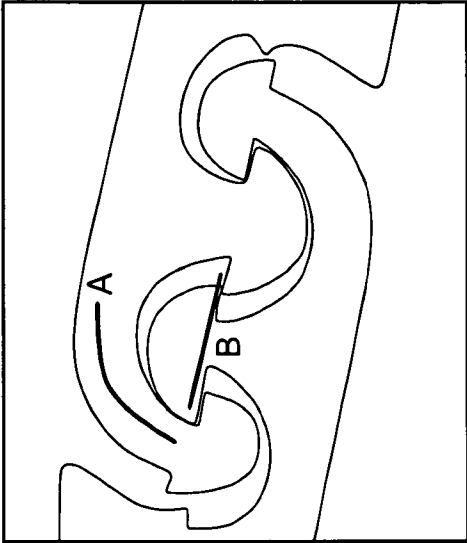


FIG. 5B

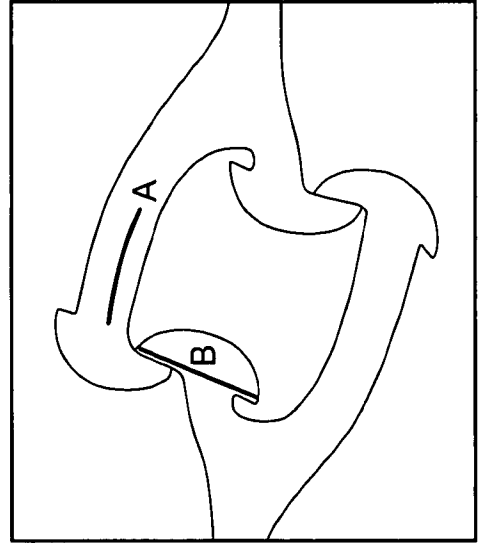


FIG. 5D

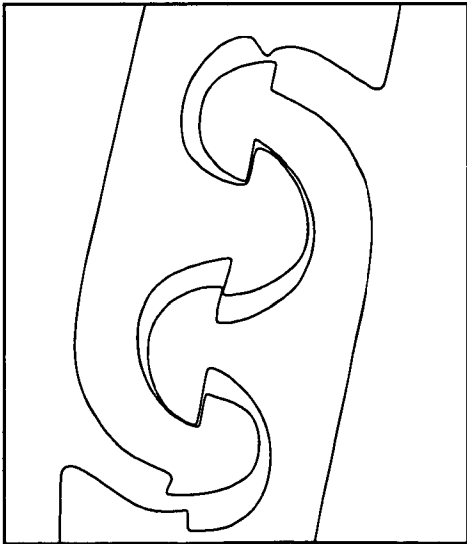


FIG. 5A

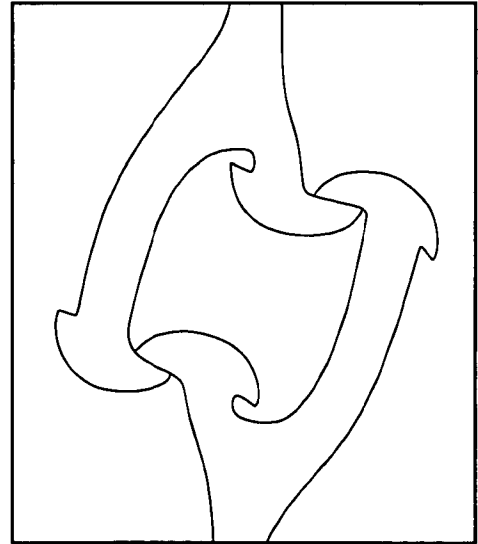


FIG. 5C

6/6

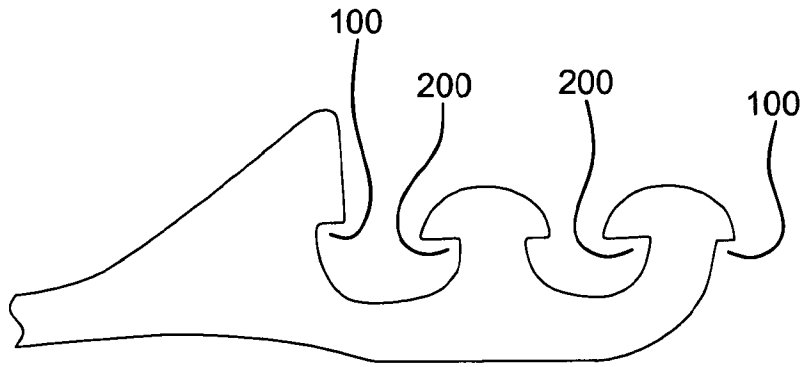


FIG. 6A
(PRIOR ART)

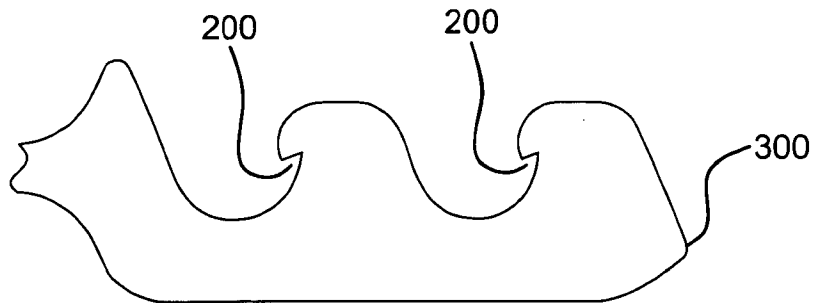


FIG. 6B

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/011012

A. CLASSIFICATION OF SUBJECT MATTER
 INV. A44B19/02 A44B19/16 A44B19/26 B65D33/25 A44B18/00

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)
 A44B B65D

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	US 5 397 182 A (GAIBLE SUSAN C [US] ET AL) 14 March 1995 (1995-03-14) column 1, lines 5-10; claim 1; figure 3 column 2, line 53 - column 3, line 34 column 4, lines 52-61 column 5, lines 25-30 column 6, lines 60-68 column 7, line 1 - column 8, line 3 <div style="text-align: center;">----- -/--</div>	1-3, 8, 10-20, 22, 31-38, 42, 44-48

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
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Date of the actual completion of the international search 5 February 2009	Date of mailing of the international search report 11/02/2009
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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 Dury, Olivier
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INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/011012

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>US 5 415 904 A (TAKUBO TOYOKAZU [JP] ET AL) 16 May 1995 (1995-05-16)</p> <p>column 1, lines 7-20; claim 1 column 2, lines 21-25,41-65</p>	<p>1-3, 7-20,22, 28,29, 31-38, 42-48</p>
X	<p>WO 03/074371 A (PACTIV CORP [US]) 12 September 2003 (2003-09-12)</p> <p>page 23, line 30 - page 24, line 3; claims 1,7,21-24</p>	<p>1-3, 7-20,22, 28,29, 31-38, 42-48</p>
E	<p>WO 2008/137135 A (GORE ENTERPRISE HOLDINGS INC [US]; HANNON GREGORY E [US]; ROSENMAYER C) 13 November 2008 (2008-11-13)</p> <p>page 2, lines 28-35; claims 1-5 page 3, lines 13-16</p>	<p>1-3,6,8, 10-22, 25, 31-37, 42,44-48</p>
X	<p>US 6 499 878 B1 (DOBRESKI DAVID V [US] ET AL) 31 December 2002 (2002-12-31) column 10, lines 31-42; claims 22,23</p>	<p>43,48</p>
X	<p>US 2005/157957 A1 (TURVEY ROBERT R [US] ET AL TURVEY ROBERT R [US] ET AL) 21 July 2005 (2005-07-21) column 12, lines 14-24; figure 32</p>	<p>43,48</p>
X	<p>US 5 119 530 A (MURABAYASHI HIROSHI [JP] ET AL) 9 June 1992 (1992-06-09)</p>	<p>1,4,5, 7-21, 45-48</p>
Y	<p>claims 1,2 column 1, lines 1-20 column 2, lines 37,49,56 examples 1-6</p>	<p>6</p>
X	<p>US 3 984 600 A (KAWASE SHOJI ET AL) 5 October 1976 (1976-10-05)</p>	<p>1,4,5, 7-21, 45-48</p>
Y	<p>column 1, lines 1-8; claim 1 column 2, line 65 - column 3, line 4 column 4, lines 44-47 column 5, lines 3-7 example 3</p>	<p>6</p>

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2008/011012

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95/27418 A (MINNESOTA MINING & MFG [US]; SHIBAHARA NORIHITO [JP]; TAKAHASHI HIROAK) 19 October 1995 (1995-10-19)	1,4,5, 7-21, 45-48
Y	claims 1-3,6,9 page 3, line 27 - page 4, line 31 pages 7-8 pages 12-14 examples; table 1	6
Y	----- US 6 592 800 B1 (LEVITT LEON [US] ET AL) 15 July 2003 (2003-07-15) column 3, lines 30-40; claims 1,17-21 column 9, lines 42-58,60,65 column 10, lines 3,5 examples 1,2	1,4-20, 45-48
Y	----- US 4 070 515 A (SMAROOK WALTER H) 24 January 1978 (1978-01-24) claims 1,10-23; figure 12 column 2, line 63 - column 3, line 40 column 7, lines 54-56 column 11, lines 45-65 column 14, lines 4-8 examples 1-9; table I	1,4-20, 45-48

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2008/011012

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search 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.:
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:
see FURTHER INFORMATION sheet PCT/ISA/210

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 No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

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

see additional sheet

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

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

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 and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

Continuation of Box II.2

Claims Nos.: -

The subject matter claimed is a.o. characterised in that the polymer compositions used should comprise a slip system additive comprising either a "lubricant" and/or a "roughening agent". These terms "lubricant" and "roughening agent" do not have accepted definitions in the art. According to the documents cited in the search report, both definitions do even overlap (compare e.g. US5415904, col. 2, lines 60-65; WO 03 074 371, page 24, lines 2-3 and the definitions of these terms as given on page 5, lines 24-28 and page 6, lines 1-5). Hence, it is not clear whether the slip system additive may also comprise a single component such as talc which may be both a lubricant and a roughening agent.

Hence, the subject matter for which protection is sought is not clearly defined (Art. 6 PCT). This non-compliance with the substantive provisions is to such an extent, that the search was performed taking into consideration the non-compliance in determining the extent of the search. The search of claims 1-52 was consequently restricted to the subject matter claimed whereing the "slip system additive" comprising at least a lubricant as defined on page 6, lines 1-5 and opt. a roughening agent as defined on page 5, lines 24-28 of the present application.

The applicant's attention is drawn to the fact that claims relating to inventions in respect of which no international search report has been established need not be the subject of an international preliminary examination (Rule 66.1(e) PCT). The applicant is advised that the EPO policy when acting as an International Preliminary Examining Authority is normally not to carry out a preliminary examination on matter which has not been searched. This is the case irrespective of whether or not the claims are amended following receipt of the search report or during any Chapter II procedure. If the application proceeds into the regional phase before the EPO, the applicant is reminded that a search may be carried out during examination before the EPO (see EPO Guideline C-VI, 8.2), should the problems which led to the Article 17(2)PCT declaration be overcome.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1(part), 2-3, 6-21 (all in part), 22-44, 45-48 (all in part), 49-52

fastener device comprising an interlocking rail comprising a lubricant dispersed in a polymeric composition

2. claims: 1(part), 4-5, 6-21 (all in part), 45-48 (all in part)

fastener device comprising interlocking set of interlocking elements comprising a lubricant dispersed in a polymeric composition

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2008/011012

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2008/011012

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
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			DE 60035360 T2	20-03-2008
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			GB 1424337 A	11-02-1976
			US 3919378 A	11-11-1975