

SHUTTER CURTAIN AND ROLLER SHUTTER WITH THERMAL INSULATION

Technical Field

- 5 **[0001]** Various embodiments generally relate to a shutter curtain and a roller shutter. In particular, various embodiments generally relate to a shutter curtain and a roller shutter with thermal insulation.

Background

- 10 **[0002]** Roller shutter has been commonly installed at the entrance of various types of premises such as retail shops, warehouses, buildings, hangars, garages, etc. for controlling physical access into the enclosed space of the respective premises. When the shutter curtain of the roller shutter is down, it provides protection against environmental factors such as wind, dust, and/or rain. It also provides security protection against intrusion or breaking in.
- 15 In certain applications, it is also required to act as a fire barrier to impede the spread of fire. Further, according to the fire codes of some countries, these fire shutters in compartment walls are also required to be insulated according to stringent standards.

- 20 **[0003]** In general, a common method of insulating a roller shutter is to provide a heat insulating slat assembly including a front shell and a rear shell coupled together to define a cavity therebetween, whereby the cavity may be filled with heat insulation material. However, the front shell and the rear shell are typically made of metal. Hence, while the roller shutter may physically prevent the spread of naked flame or be resistant to catching fire, such a configuration would still allow heat to conduct through the roller shutter via heat conduction between the front shell and the rear shell of each slat assembly.

- 25 **[0004]** Accordingly, there is a need for a more effective solution to address the above issues, for example to provide shutter curtain or roller shutter with better heat insulation capability.

Summary

- 30 **[0005]** According to various embodiments, there is provided a shutter curtain. The shutter curtain including at least two primary slats pivotally interlocked in a longitudinal-edge-to-

longitudinal-edge arrangement one after another. Each of the at least two primary slats includes an elongated primary-slat-body having a longitudinal axis. The elongated primary-slat-body is integrally formed with a first interlockable longitudinal edge portion and a second interlockable longitudinal edge portion. The first interlockable longitudinal edge portion and the second interlockable longitudinal edge portion of the elongated primary-slat-body are opposite each other on opposite sides of the longitudinal axis of the elongated primary-slat-body. The first interlockable longitudinal edge portion of the elongated primary-slat-body of a first primary slat of the at least two primary slats is pivotally interlocked with the second interlockable longitudinal edge portion of the elongated primary-slat-body of a second primary slat of the at least two primary slats to form a pivotable joint between the at least two primary slats. A pivot axis of the pivotable joint is parallel to the longitudinal axis of the elongated primary-slat-body. The shutter curtain further including at least two secondary slats unconnected from each other, and at least two thermal insulating units respectively connected between the at least two primary slats and the at least two secondary slats to hold apart each of the at least two primary slats and a corresponding one of the at least two secondary slats in a manner so as to thermally separate said primary slat from said secondary slat.

[0006] According to various embodiments, there is provided a roller shutter. The roller shutter including a drum and the shutter curtain as described herein, wherein the shutter curtain is attached to the drum in a manner so as to be capable of being rolled on and off the drum when the drum is being rotated.

Brief description of the drawings

[0007] In the drawings, like reference characters generally refer to the same parts throughout the different views. The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments are described with reference to the following drawings, in which:

FIG. 1A shows a shutter curtain according to various embodiments;

FIG. 1B shows two links of the shutter curtain of FIG. 1A according to various embodiments;

FIG. 2 shows a roller shutter with the shutter curtain of FIG. 1A according to various embodiments;

FIG. 3A shows a shutter curtain according to various embodiments;

FIG. 3B shows two links of the shutter curtain of FIG. 3A according to various
5 embodiments; and

FIG. 4 shows a roller shutter with the shutter curtain of FIG. 3A according to various embodiments.

Detailed description

[0008] Embodiments described below in the context of the apparatus are analogously
10 valid for the respective methods, and vice versa. Furthermore, it will be understood that the embodiments described below may be combined, for example, a part of one embodiment may be combined with a part of another embodiment.

[0009] It should be understood that the terms “on”, “over”, “top”, “bottom”, “down”, “side”, “back”, “left”, “right”, “front”, “lateral”, “side”, “up”, “down” etc., when used in the
15 following description are used for convenience and to aid understanding of relative positions or directions, and not intended to limit the orientation of any device, or structure or any part of any device or structure. In addition, the singular terms “a”, “an”, and “the” include plural references unless context clearly indicates otherwise. Similarly, the word “or” is intended to include “and” unless the context clearly indicates otherwise.

[00010] Various embodiments generally relate to a shutter curtain. In particular, various
20 embodiments generally relate to a shutter curtain for insulating heat. Various embodiments also relate to a roller shutter including the shutter curtain of the various embodiments.

[00011] According to various embodiments, the shutter curtain may include a first set of interconnected slats (or primary slats) which may be pivotably connected one after another.
25 The shutter curtain may include a second set of unconnected slats (or secondary slats) which may be independent and not joined to each other. Each unconnected slat may be held apart from a corresponding slat of the first set of interconnected slats in a manner so as to be thermally insulated from the corresponding slat. The term “thermally insulated” used in the following description generally refers to reduction in thermal conduction, for example by
30 creating a thermal break or thermal barrier, as well as preventing thermal conduction, for example via thermal isolation or thermal separation. According to various embodiments, a

thermal insulating unit may be connected between said unconnected slat and the corresponding slat to thermally insulate (e.g. to form a thermal break or thermal barrier between, or to thermally isolate or thermally separate) said unconnected slat and the corresponding slat. The thermal insulating unit may have a configuration (e.g. in terms of materials, structure, shape, assembly etc.) with sufficient rigidity so as to be capable of holding apart said unconnected slat and the corresponding slat. Since said unconnected slat is only in contact with one side of the thermal insulating unit and the corresponding slat is in contact with another side (e.g. opposite side) of the thermal insulating unit, said unconnected slat and the corresponding slat may not have any direct contact. Further, said unconnected slat and the corresponding slat may not be connected by any heat conductive component or may only have negligible or insignificant or minimal heat conductive components therebetween. Hence, the thermal insulating unit may reduce or prevent flow of thermal energy between said unconnected slat and the corresponding slat. For example, when the thermal insulating unit serve as a thermal break or thermal barrier, the thermal insulating unit may provide a high thermal resistance to reduce the flow of thermal energy. When the thermal insulating unit serve to thermally isolate or separate said unconnected slat and the corresponding slat, said unconnected slat and the corresponding slat may be free of any direct heat conduction path or “thermal bridge” therebetween. Thus, the thermal insulating unit may serve to reduce or resist or obstruct or break or isolate or cut any thermal transfer, e.g. thermal conduction, between said unconnected slat and the corresponding slat. Therefore, the thermal insulation integrity between said unconnected slat and the corresponding slat may be fully preserved and the thermal insulating unit may be effective in providing thermal insulation between said unconnected slat and the corresponding slat for reducing or preventing thermal conduction. According to various embodiments, the thermal insulating unit may be made of wood, ceramic, plastic, glass, carbon, etc or a combination thereof. At the same time, with the first set of interconnected slats pivotably connected and the second set of unconnected slats individually connected to the corresponding slats of the first set of interconnected slats via respective the thermal insulating unit, the shutter curtain may be rolled up and down via a single drum, which may preserve the usual configuration and operation of a roller shutter. Hence, leading to simpler manufacturing process, easier integration to existing structures/parts, and lower costs.

[00012] According to various embodiments, when the shutter curtain is rolled down and deployed, the first set of interconnected slats may form a first side of the shutter curtain, and

the second set of unconnected slats may be stacked onto each other to form a second side of the shutter curtain. Since each of the unconnected slats is held apart from the corresponding slat of the first set of interconnected slats by the thermal insulating unit, the first side of the shutter curtain may be thermally insulated from the second side of the shutter curtain.

5 Further, with the first side of the shutter curtain formed by the first set of interconnected slats, the interconnected slats may also serve as a physical barrier to block out dust, water, wind, and/or naked flame from passing through the first side of the shutter curtain. In addition, the second set of unconnected slats may also be stacked in a continuous manner so as to form a physical barrier to similarly block out dust, water, wind, and/or naked flame
10 from passing through the second side of the shutter curtain. Accordingly, the shutter curtain of the various embodiments may be effective to serve as a secure physical barrier (either on the first side or second side or both) as well as to provide thermal insulation to reduce or prevent spreading of heat, e.g. via conduction, through the shutter curtain (from the first side to the second side, or from the second side to the first side) in case of a fire.

15 **[00013]** According to various embodiments, each unconnected slat of the second set of unconnected slats may include a retaining arrangement to hold or couple to a first end of a corresponding thermal insulating unit and each corresponding slat of the first set of interconnected slats may include a retaining arrangement to hold or couple to a second end of the corresponding thermal insulating unit. According to various embodiments, the
20 retaining arrangements may be respectively configured to enable the corresponding thermal insulating unit to connect said unconnected slat of the second set of unconnected slats to said corresponding slat of the first set of interconnected slats without any fasteners (i.e. without rivets, screw, nails, bolts, etc.). Hence, said unconnected slat of the second set of unconnected slats may be connected to said corresponding slat of the first set of
25 interconnected slats without any fasteners.

[00014] According to various embodiments, each unconnected slat of the second set of unconnected slats may include a first engagement longitudinal portion and a second engagement longitudinal portion opposite the first engagement longitudinal portion. According to various embodiments, when the shutter curtain is rolled down and deployed,
30 the second set of unconnected slats may be stacked onto each other in a manner such that the first engagement longitudinal portion of one unconnected slat may be stacked and engaged with the second engagement longitudinal portion of an adjacent unconnected slat. The engagement between adjacent slats of the second set of unconnected slats may be in a

mesh or an interlocking manner so as to form a separable lap joint or separable overlap joint or a separable tongue-and-groove joint. Accordingly, the second set of unconnected slats may form a secure physical barrier to block out dust, water, wind, and/or naked flame when the shutter curtain is rolled down and deployed. According to various embodiments, the first engagement longitudinal portion may be a male engagement portion and the second engagement longitudinal portion may be a female engagement portion, or vice versa.

[00015] According to various embodiments, each unconnected slat of the second set of unconnected slats may be integrally roll-formed from a sheet of material (e.g. a sheet of metal, a sheet of aluminium, etc.) to include the first engagement longitudinal portion, the second engagement longitudinal portion, and the retaining arrangement. Accordingly, the first engagement longitudinal portion, the second engagement longitudinal portion, and the retaining arrangement of each unconnected slat may be formed via roll-forming the sheet of material. According to various embodiments, each corresponding slat of the first set of interconnected slats may be integrally roll-formed from a sheet of material (e.g. a sheet of metal, a sheet of aluminium, etc.) to include a first interlockable longitudinal edge portion, a second interlockable longitudinal edge portion, and the retaining arrangement, wherein the first interlockable longitudinal edge portion and the second interlockable longitudinal edge portion are configured for the first set of interconnected slats (or primary slats) to be pivotably connected one after another. Accordingly, the first interlockable longitudinal edge portion, the second interlockable longitudinal edge portion, and the retaining arrangement of the corresponding slat may be formed via roll-forming the sheet of material.

[00016] According to various embodiments, additional non-rigid insulating materials may be disposed between each unconnected slat of the second set of unconnected slats and each corresponding slat of the first set of interconnected slats. Accordingly, the additional non-rigid insulating materials may be disposed to fill up remaining spaces (unoccupied by the thermal insulating unit) between said unconnected slat and said corresponding slat to enhance the thermal insulation effectiveness of the shutter curtain. According to various embodiments, the additional non-rigid insulating materials may include mineral wool, fiberglass, cellulose, polystyrene, polyurethane foam, etc.

[00017] FIG. 1A shows a shutter curtain 101 according to various embodiments and FIG. 1B shows two links of the shutter curtain 101 of FIG. 1A pivoted with respect to each other according to various embodiments. FIG. 1C shows a disassembled view of a link of the shutter curtain 101 of FIG. 1A according to various embodiments, FIG. 1D shows an

assembled view of a link of the shutter curtain 101 of FIG. 1A according to various embodiments. FIG. 1E shows a front view of the link of FIG. 1D according to various embodiments.

[00018] According to various embodiments, the shutter curtain 101 may include at least
 5 two (or two or more, or a plurality of) primary slats 110. The at least two primary slats 110 may be pivotally interlocked in a longitudinal-edge-to-longitudinal-edge arrangement one after another. Accordingly, the at least two primary slats 110 may be connected or engaged in a manner in which two immediately adjacent primary slats 110 may be pivotable relative to each other along respective longitudinal-edge-to-longitudinal-edge connections or
 10 engagements. According to various embodiments, when the shutter curtain 101 is deployed, the at least two primary slats 110 may form a first side 101a of the shutter curtain 101.

[00019] According to various embodiments, each of the at least two primary slats 110 may include an elongated primary-slat-body 112. The elongated primary-slat-body 112 may have a longitudinal axis. Accordingly, the elongated primary-slat-body 112 may be a narrow strip
 15 of material, for example metal such as steel or aluminum, extending along the longitudinal axis of the elongated primary-slat-body 112. According to various embodiments, the elongated primary-slat-body 112 may be integrally formed with a first interlockable longitudinal edge portion 114 and a second interlockable longitudinal edge portion 116. The first interlockable longitudinal edge portion 114 and the second interlockable longitudinal
 20 edge portion 116 of the elongated primary-slat-body 112 may be opposite each other on opposite sides of (or across) the longitudinal axis of the elongated primary-slat-body 112. The first interlockable longitudinal edge portion 114 and the second interlockable longitudinal edge portion 116 of the elongated primary-slat-body 112 may be parallel to the longitudinal axis of the elongated primary-slat-body 112, and may be the two outermost
 25 longitudinal portions of the elongated primary-slat-body 112.

[00020] According to various embodiments, the first interlockable longitudinal edge portion 114 of the elongated primary-slat-body 112 of a first primary slat 110a of the at least two primary slats 110 may be pivotally interlocked with the second interlockable longitudinal edge portion 116 of the elongated primary-slat-body 112 of a second primary
 30 slat 110b of the at least two primary slats 110 to form a pivotable joint 115 between the at least two primary slats 110 (for example see FIG. 1B). The first primary slat 110a and the second primary slat 110b may be two immediately adjacent primary slats 110. Accordingly, the pivotable joint 115 between the first interlockable longitudinal edge portion 114 of the

elongated primary-slat-body 112 of the first primary slat 110a and the second interlockable longitudinal edge portion 116 of the elongated primary-slat-body 112 of the second primary slat 110b may form the longitudinal-edge-to-longitudinal-edge connections or engagements lengthwise between the first primary slat 110a and the second primary slat 110b (or the two immediately adjacent primary slats 110). In other words, the first primary slat 110a and the second primary slat 110b (or the two immediately adjacent primary slats 110) may be connected or engaged along respective longitudinal edge portions 114, 116 between the first primary slat 110a and the second primary slat 110b (or the two immediately adjacent primary slats 110) so as to be interlocked or coupled or connected or attached to each other along the respective longitudinal edge portions 114, 116 (or the pivot joint 115). Further, the first primary slat 110a and the second primary slat 110b (or the two immediately adjacent primary slats 110) may be pivotally interlocked to each other along an entire length thereof. According to various embodiments, a pivot axis of the pivotable joint 115 may be parallel to the longitudinal axis of the elongated primary-slat-body 112. Accordingly, the first primary slat 110a and the second primary slat 110b (or the two immediately adjacent primary slats 110) may be pivotable relative to each other about the pivot axis of the pivotable joint 115, and may be so connected or engaged such that the first primary slat 110a and the second primary slat 110b (or the two immediately adjacent primary slats 110) may be interlocked and non-separable in a direction perpendicular to the pivot axis.

[00021] According to various embodiments, the elongated primary-slat-body 112 may include an exterior surface 112a and an interior surface 112b. The exterior surface 112a of the elongated primary-slat-body 112 may be an exposed surface directed outwards from the shutter curtain 101 (or an outward facing surface). The interior surface 112b of the elongated primary-slat-body 112 may be directed towards (or facing) an interior space 101c of the shutter curtain 101. According to various embodiments, the first interlockable longitudinal edge portion 114 of the elongated primary-slat-body 112 may be an inward curl portion formed by curling a first longitudinal edge 113 of the elongated primary-slat-body 112 inwards with respect to the interior surface 112b and towards the longitudinal axis of the elongated primary-slat-body 112. According to various embodiments, the second interlockable longitudinal edge portion 116 of the elongated primary-slat-body 112 may be an outward curl portion formed by curling a second longitudinal edge 117 of the elongated primary-slat-body 112 outwards with respect to the exterior surface 112a and towards the longitudinal axis of the elongated primary-slat-body 112.

[00022] According to various embodiments, a curl radius of the inward curl portion (or the first interlockable longitudinal edge portion 114) of the elongated primary-slat-body 112 may be smaller than an outward curl portion (or the second interlockable longitudinal edge portion 116) of the elongated primary-slat-body 112. Accordingly, the first primary slat 110a and the second primary slat 110b may be joined or connected or interlocked together by, for example, fitting or overlapping or interlocking or joining or coupling or connecting the inward curl portion (or the first interlockable longitudinal edge portion 114) of the elongated primary-slat-body 112 of the first primary slat 110a and the outward curl portion (or the second interlockable longitudinal edge portion 116) of the elongated primary-slat-body 112 of the second primary slat 110b together to form the pivot joint 115 such that the first primary slat 110a and the second primary slat 110b may be pivotable relative to each other about the pivot joint 115. For example, referring to FIG. 1B, the outward curl portion (or the second interlockable longitudinal edge portion 116) of the elongated primary-slat-body 112 of the second primary slat 110b may be fitted over or wrapped over the inward curl portion (or the first interlockable longitudinal edge portion 114) of the elongated primary-slat-body 112 of the first primary slat 110a such that they may be interlockably pivotable.

[00023] According to various embodiments, the shutter curtain 101 may include at least two (or two or more, or a plurality of) secondary slats 120. The at least two secondary slats 120 may be unconnected from each other. Accordingly, the at least two secondary slats 120 may be independent and may not be joined to each other. Hence, unlike the at least two primary slats 110, the at least two secondary slats 120 may not be interconnected and may be separable from each other. According to various embodiments, when the shutter curtain 101 is deployed, the at least two secondary slats 120 may form a second side 101b of the shutter curtain 101. The first side 101a and the second side 101b of the shutter curtain 101 may be opposite sides of the shutter curtain 101.

[00024] According to various embodiments, the shutter curtain 101 may include at least two thermal insulating units 130. The at least two thermal insulating units 130 may be connected between the at least two primary slats 110 and the at least two secondary slats 120 to hold apart each of the at least two primary slats 110 and a corresponding one of the at least two secondary slats 120 in a manner so as to thermally insulate (e.g. thermally separate) said primary slat 110 from said secondary slat 120. Accordingly, the at least two thermal insulating unit 130 may thermally insulate (e.g. thermally separate) each of the at

least two primary slats 110 from the corresponding one of the at least two secondary slats 120. In other words, each of the at least two thermal insulating units 130 may be connected between one of the at least two primary slats 110 and a corresponding one of the at least two secondary slats 120 to hold apart said primary slat 110 and said secondary slat 120 in a manner so as to thermally insulate (e.g. thermally separate) said primary slat 110 from said secondary slat 120. For example, the first primary slat 110a of the at least two primary slats 110 and a first secondary slat 120a of the at least two secondary slats 120 may be held apart by a first thermal insulating unit 130a of the at least to two thermal insulating units 130 to thermally insulate (e.g. thermally separate) the first primary slat 110a and the first secondary slat 120a. Similarly, the second primary slat 110b of the at least two primary slats 110 and a second secondary slat 120b of the at least two secondary slats 120 may be held apart by a second thermal insulating unit 130b of the at least to two thermal insulating units 130 to thermally insulate (e.g. thermally separate) the second primary slat 110b and the second secondary slat 120b.

[00025] According to various embodiments, each of the at least two primary slats 110 may be in contact with one portion (e.g. a first portion 134) of a corresponding thermal insulating unit 130, and a corresponding one of the at least two secondary slats 120 may be in contact with another portion (e.g. a second portion 136) of the corresponding thermal insulating unit 130. According to various embodiments, said thermal insulating unit 130 may thermally separate said primary slat 110 and said corresponding secondary slat 120 in a manner such that said primary slat 110 may not be in any direct contact with said corresponding secondary slat 120. Further, said thermal insulating unit 130 may be connected between said primary slat 110 and said secondary slat 120 without any other thermal conductive component connected therebetween. Thus, said primary slat 110 and said secondary slat 120 may be free of any direct heat conduction path or “thermal bridge” therebetween. Therefore, said thermal insulating unit 130 may serve to break or isolate or cut thermal conduction between said primary slat 110 and said secondary slat 120. Hence, the thermal insulation integrity between said primary slat 110 and said secondary slat 120 may be preserved and said thermal insulating unit 130 may effectively thermally insulate (e.g. thermally separate) said primary slat 110 from said secondary slat 120, and vice versa.

[00026] According to various embodiments, the shutter curtain 101 including the at least two primary slats 110 pivotably interconnected to form the first side 101a of the shutter curtain 101 may have a continuous and seamless side serving as a physical barrier to block

out dust, water, wind, and/or naked flame when the shutter curtain 101 is deployed. Each of the at least two primary slats 110 being pivotably interlock to another of the at least two primary slats 110 along respective longitudinal edge portions 114, 116 may provide direct overlapping connections along the respective longitudinal edge portions 114, 116 lengthwise in a manner such that the first side 101a of the shutter curtain 101 may be free of any gaps between the at least two primary slats. Accordingly, two immediately adjacent primary slats 110 of the at least two primary slats may be interconnected continuously and seamlessly lengthwise entirely along the respective longitudinal edge portions 114, 116. Hence, the at least two primary slats 110 pivotably interconnected to form the first side 101a of the shutter curtain 101 may directly serve as the physical barrier without requiring (i.e. free of) additional seal or plug or rubber along the respective longitudinal edge portions 114, 116. Further, with the elongated primary-slat-body 112 of each of the at least two primary slats 110 being a one-piece structure having the first interlockable longitudinal edge portion 114 and the second interlockable longitudinal edge portion 116, the at least two primary slats 110 may be directly interconnected one after another without requiring (i.e. free of) any additional connection bar or strap connected to the slat body, or any hinge/joint component for such additional connection bar or strap. Direct interconnection between the at least two primary slats may provide better durability and reliability to prolong the lifespan of the shutter curtain 101 in view that such shutter curtain 101 may be repeatedly retracted and deployed daily. In addition, with the at least two thermal insulating material 130 and the at least two secondary slats 120, the shutter curtain 101 may additionally provide thermal insulation capability in a simple, effective and easy manner while having the continuous and seamless first side 101a. As previously described, the at least two secondary slats 120 may form the second side 101b of the shutter curtain 101, and the at least two thermal insulating unit 130 may thermally insulate (e.g. thermally separate) the at least two secondary slats 120 and the at least two primary slats 110. Accordingly, the first side 101a and the second side 101b of the shutter curtain 101 may be thermally insulated (e.g. thermally separated) from each other via the at least two thermal insulating material 130. According to various embodiments, the shutter curtain 101 may provide a simple and sleek configuration with thermal insulation capability, whereby the at least two primary slats 110 may form the continuous and seamless first side 101a of the shutter curtain 101, the at least two secondary slats 120 may form the second side 101b of the shutter curtain 101, and the at least two thermal insulating unit 130 may thermally insulate (e.g. thermally separate) the first side

101a and the second side 101b of the shutter curtain 101, without requiring additional components to join the slats together or to insulate the first side and the second side.

[00027] According to various embodiments, each of the at least two thermal insulating unit 130 may include a rigid thermal-insulating-body 132. The rigid thermal-insulating body 132 may include the first portion 134 and the second portion 136, wherein the first portion 134 and the second portion 136 are opposite portions of the rigid thermal-insulating body 132. The rigid thermal-insulating body 132 may be stiff or unyielding or non-pliant or non-flexible such that the rigid thermal-insulating body 132 may firmly hold a corresponding one of the at least two primary slats 110 and a corresponding one of the at least two secondary slats 120 in a fixed disposition relative to each other. Accordingly, the rigid thermal-insulating body 132 may have a rigidity or stiffness to fixedly hold said primary slat 110 and said secondary slat 120 in a manner such that said primary slat 110 and said secondary slat 120 may be immovable relative to each other. Hence said primary slat 110 and said secondary slat 120 may be held in place in the fixed disposition relative to each other by the rigid thermal-insulating body 132. According to various embodiments, the rigid thermal-insulating body 132 may include a slab or panel or block of rigid solid thermal-insulating material including, but not limited to, wood, ceramic, plastic, glass, or carbon. According to various embodiments, the rigid thermal-insulating body 132 may include, but not limited to a rigid solid structure/shape, a rigid lattice structure/shape, or a rigid frame structure/shape. According to various embodiments, the rigid thermal-insulating body 132 may include, but not limited to, a rigid composite assembly such as a sandwich-structured composite, or a rigid composite material such as fibre-reinforced plastic or glass-reinforced plastic. According to various embodiments, when the rigid thermal-insulating body 132 is a rigid composite assembly or a rigid composite material, the rigid thermal-insulating body 132 may include one or a combination of thermal-insulating material including, but not limited to, wood, ceramic, plastic, glass, carbon, mineral wool, fiberglass, cellulose, polystyrene, polyurethane foam, etc.

[00028] According to various embodiments, each of the at least two secondary slats 120 may include an elongated secondary-slat-body 122. The elongated secondary-slat-body 122 may have a longitudinal axis. Accordingly, the elongated secondary-slat-body 122 may be a narrow strip of material, for example metal such as steel or aluminum, extending along the longitudinal axis of the elongated secondary-slat-body 122. According to various embodiments, the elongated secondary-slat body 122 may be integrally formed with a first

engagement longitudinal portion 124 and a second engagement longitudinal portion 126. The first engagement longitudinal portion 124 and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 may be opposite each other on opposite sides of (or across) the longitudinal axis of the elongated secondary-slat-body 122.

5 The first engagement longitudinal portion 124 and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 may be parallel to the longitudinal axis of the elongated secondary-slat-body 122.

[00029] According to various embodiments, the first engagement longitudinal portion 124 and the second engagement longitudinal portion 126 may be configured to be releasably
 10 engageable to each other. According to various embodiments, the elongated secondary-slat-body 122 of a first secondary slat 120a of the at least two secondary slats 120 may be stackable on the elongated secondary-slat-body 122 of a second secondary slat 120b of the at least two secondary slats 120 with the first engagement longitudinal portion 124 of the elongated secondary-slat-body 120 of the first secondary slat 120a in engagement with the
 15 second engagement longitudinal portion 126 of the elongated secondary-slat-body 120 of the second secondary slat 120b. The first secondary slat 120a and the second secondary slat 120b may be two immediately adjacent secondary slats 120. According to various embodiments, when the shutter curtain 101 is deployed, the at least two secondary slats 120 may be stacked one after another to form the second side 101b of the shutter curtain 101.
 20 Accordingly, the first secondary slat 120a and the second secondary slat 120b (or the two immediately adjacent secondary slats 120) may be stacked one over the other in a manner such that the first engagement longitudinal portion 124 of the elongated secondary-slat-body 120 of the first secondary slat 120a may be stacked on and in engagement with the second engagement longitudinal portion 126 of the elongated secondary-slat-body 120 of the
 25 second secondary slat 120b. According to various embodiments, the engagement between the first engagement longitudinal portion 124 of the elongated secondary-slat-body 120 of the first secondary slat 120a and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 120 of the second secondary slat 120b (or between the first engagement longitudinal portion 124 and the second engagement longitudinal portion 126
 30 respectively of the two immediately adjacent secondary slats 120) may be seamless and free of any gaps such that the second side 101b of the shutter curtain 101 formed by the at least two secondary slats 120 may also serve as a physical barrier to block out dust, water, wind, and/or naked flame when the shutter curtain 101 is deployed. Accordingly, two immediately

adjacent secondary slats 120 of the at least two secondary slats 120 may be stacked to be in engagement with each other continuously and seamlessly lengthwise entirely along the respective first engagement longitudinal portion 124 and second engagement longitudinal portion 126. According to various embodiments, when the shutter curtain 101 is deployed, with the first side 101a of the shutter curtain 101 (e.g. formed by the at least two primary slats 110 pivotably interlocked together) and the second side 101b of the shutter curtain 101 (e.g. formed by the at least two secondary slats 120 stacked together) impervious to dust, water, wind, and/or naked flame, the thermal insulation capability of the shutter curtain 101 may be enhanced or become more effective as thermal radiation and/or thermal convection may be minimised or eliminated while the at least two thermal insulating unit 130 therebetween may break or isolate or cut thermal conduction.

[00030] According to various embodiments, the engagement between the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122 of the first secondary slat 120a and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 of the second secondary slat 120b may be a mesh-type engagement, whereby the first engagement longitudinal portion 124 and the second engagement longitudinal portion 126 may have matching profiles such that the first engagement longitudinal portion 124 and the second engagement longitudinal portion 126 may be inter-fitted to each other in a mesh-like manner. For example, the first engagement longitudinal portion 124 and the second engagement longitudinal portion 126 may be inter-fitted to each other whereby some portions may overlap or lap over, or some portion(s) may be inserted in corresponding portion(s). According to various embodiments, the engagement between the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122 of the first secondary slat 120a and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 of the second secondary slat 120b may form a joint including, but not limited to, a separable lap joint, a separable overlap joint, or a separable tongue-and-groove joint.

[00031] According to various embodiments, a cross-section of the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 may include an insert profile and a cross-section of the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 may include a complementary recess profile. According to various embodiments, the insert profile may be an extension or protrusion forming a

tongue, a tenon, or a skirt-like portion or the like for lapping over or insertion, and the recess profile may include a groove, a slot, a ledge, a step, a shoulder or the like for receiving or accommodating the insert profile to form the lap joint, the overlap joint, or the tongue-and-groove joint. According to various embodiments, the insert profile may be tapered and the recess profile may have a complementary slope.

[00032] According to various embodiments, the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 may further include a retaining arrangement 128. The retaining arrangement 128 of the elongated secondary-slat-body 122 may hold the first portion 134 of the rigid thermal-insulating body 132 of a corresponding one of the at least two thermal insulating units 130 to the elongated secondary-slat-body 120. According to various embodiments, the retaining arrangement 128 of the elongated secondary-slat-body 122 may hold, or support, or secure the first portion 134 of the rigid thermal-insulating body 132 to the elongated secondary-slat-body 122 so as to keep the rigid thermal-insulating body 132 from falling in order to maintain it in position with respect to the elongated secondary-slat-body 122. Hence, the retaining arrangement 128 of the elongated secondary-slat-body 122 may hold or support, or secure the first portion 134 of the rigid thermal-insulating body 132 in a fixed disposition relative to each other. According to various embodiments, the retaining arrangement 128 of the elongated secondary-slat-body 122 may be in direct engagement with the first portion 134 of the rigid thermal-insulating body 132 as shown in FIG. 1A to FIG. 1B. Accordingly, the first portion 134 of the rigid thermal-insulating body 132 may be in direct contact or abutment with the retaining arrangement 128 of the elongated secondary-slat-body 122.

[00033] According to various embodiments, the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 may include a first longitudinal edge portion 125 and a second longitudinal edge portion 127. The first longitudinal edge portion 125 and the second longitudinal edge portion 127 of the elongated secondary-slat-body 122 may be opposite each other on opposite sides of (or across) the longitudinal axis of the elongated secondary-slat-body 122. The first longitudinal edge portion 125 and the second longitudinal edge portion 127 of the elongated secondary-slat-body 122 may be parallel to the longitudinal axis of the elongated secondary-slat-body 122, and may be the two opposite longitudinal portions at which the elongated secondary-slat-body 122 terminates. According to various embodiments, the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122 may be immediately adjacent to the first longitudinal edge portion

125 of the elongated secondary-slat-body 122, and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 may be immediately adjacent to the second longitudinal edge portion 127 of the elongated secondary-slat-body 122.

[00034] According to various embodiments, the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 may include a main portion 129 between the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122 and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122. The main portion 129 of the elongated secondary-slat-body 122 may be a broadest longitudinal section of the elongated secondary-slat-body 122 which may be lined abreast or placed side-by-side with the main portion of the elongated secondary-slat-body 122 of an adjacent secondary slats 120 so as to form the second side 101b of the shutter curtain 101. Accordingly, the main portions 129 of the at least two secondary slats may together form the second side 101b of the shutter curtain 101. According to various embodiments, the main portion 129 of the elongated secondary-slat-body 122 may be of a rectangular planar shape or a long rectangular planar shape. Further, the main portion 129 of the elongated secondary-slat-body 122 may be between the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122 and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 such that the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122 and the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 may respectively be along two opposite longest sides of the main portion 129 of the elongated secondary-slat-body 122. According to various embodiments, the first engagement longitudinal portion 124 may be between the first longitudinal edge portion 125 and the main portion 129 of the elongated secondary-slat-body 122, and the second engagement longitudinal portion 126 may be between the second longitudinal edge portion 127 and the main portion 129 of the elongated secondary-slat-body 122.

[00035] According to various embodiments, the retaining arrangement 128 of the elongated secondary-slat-body 122 may include a pair of opposing lip formations 128a, 128b extending towards each other from opposite longitudinal edge portions 125, 127 of the elongated secondary-slat-body 122. A first lip formation 128a of the pair may be between the first engagement longitudinal portion 124 and the first longitudinal edge portion 125. A second lip formation 128b of the pair may be between the second engagement longitudinal portion 126 and the second longitudinal edge portion 127. The first lip formation 128a may

be a protrusion extending away from the first engagement longitudinal portion 124 and/or the first longitudinal edge portion 125 in a manner parallel to the main portion 129 of the elongated secondary-slat-body 122 so as to define a first channel between the first lip formation 128a and the main portion 129 of the elongated secondary-slat-body 122. The second lip formation 128b may be a protrusion extending away from the second engagement longitudinal portion 126 and/or the second longitudinal edge portion 127 in a manner parallel to the main portion 129 of the elongated secondary-slat-body 122 so as to define a second channel between the second lip formation 128b and the main portion 129 of the elongated secondary-slat-body 122. Further, the first lip formation 128a and the second lip formation 128b may be extending towards each other with respect to the main portion 129 of the elongated secondary-slat-body 122 such that the first channel and the second channel respectively formed therebetween may be two opposing channels (i.e. directed towards each other or facing each other).

[00036] According to various embodiments, each of the pair of opposing lip formations 128a, 128b of the retaining arrangement 128 of the elongated secondary-slat-body 122 may be formed by folding over a corresponding segment of the elongated secondary-slat-body 122. Accordingly, the first lip formation 128a may be formed by folding over a corresponding first segment of the elongated secondary-slat-body 122 to form a hem-like or pleat-like formation extending alongside the first engagement longitudinal portion 124 and/or the first longitudinal edge portion 125. Similarly, the second lip formation 128b may be formed by folding over a corresponding second segment of the elongated secondary-slat-body 122 to form a hem-like or pleat-like formation extending alongside the second engagement longitudinal portion 126 and/or the second longitudinal edge portion 127. According to various embodiments, each of the pair of opposing lip formations 128a, 128b of the retaining arrangement 128 of the elongated secondary-slat-body 122 may be parallel to the longitudinal axis of the elongated secondary-slat-body 122 as well as parallel to the main portion 129 of the elongated secondary-slat-body 122.

[00037] According to various embodiments, the first portion 134 of the rigid thermal-insulating body 132 of each of the at least two thermal insulating units 130 may include an engagement arrangement 135 for coupling the first portion 134 of the rigid thermal-insulating body 132 to the elongated secondary-slat-body 122 of a corresponding secondary slat 120 of the at least two secondary slats. Accordingly, the engagement arrangement 135 of the first portion 134 of the rigid thermal-insulating body 132 may engage with the

retaining arrangement 128 of the elongated secondary-slat-body 122 to couple the first portion 134 of the rigid thermal-insulating body 132 to the elongated secondary-slat-body 122. According to various embodiments, the engagement arrangement 135 of the first portion 134 of the rigid thermal-insulating body 132 may include a profile complementary to the retaining arrangement 128 of the elongated secondary-slat-body 122 to facilitate engagement and coupling. Hence, depending on the configuration of the retaining arrangement 128 of the elongated secondary-slat-body 122, the engagement arrangement 135 of the first portion 134 of the rigid thermal-insulating body 132 may be configured accordingly.

10 **[00038]** Referring to FIG. 1A and FIG. 1B, according to various embodiments, when the retaining arrangement 128 of the elongated secondary-slat-body 122 includes the pair of opposing lip formations 128a, 128b, the engagement arrangement 135 of the first portion 134 of the rigid thermal-insulating body 132 may include a pair of transverse protrusions 135a, 135b. According to various embodiments, the pair of transverse protrusions 135a, 135b may be extending transversely in opposite directions with respect to the rigid thermal-insulating body 132. Accordingly, the pair of transverse protrusions 135a, 135b may be extending sideways or laterally from the rigid thermal-insulating body 132. According to various embodiments, the pair of transverse protrusions 135a, 135b of the first portion 134 of the rigid thermal-insulating body 132 may be in engagement with the pair of opposing lip formations 128a, 128b of the retaining arrangement 128 of the elongated secondary-slat-body 122 of a corresponding secondary slat 120 for connecting the first portion 134 of the rigid thermal-insulating body 132 to the elongated secondary-slat-body 122. According to various embodiments, the first transverse protrusion 135a of the pair may be inserted into the first channel formed between the first lip formation 128a of the retaining arrangement 128 of the elongated secondary-slat-body 122 and the main portion 129 of the elongated secondary-slat-body 122, and the second transverse protrusion 135b of the pair may be inserted into the second channel formed between the second lip formation 128b of the retaining arrangement 128 of the elongated secondary-slat-body 122 and the main portion 129 of the elongated secondary-slat-body 122. Accordingly, the retaining arrangement 128 and the main portion 129 of the elongated secondary-slat-body 122 may cooperatively retain or hold or secure the pair of transverse protrusions 135a, 135b of the first portion 134 of the rigid thermal-insulating body 132 to keep or maintain the rigid thermal-insulating body 132 in the fixed disposition with respect to the elongated secondary-slat-body 122.

[00039] According to various embodiments, the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 may include an exterior surface 122a and an interior surface 122b. The exterior surface 122a of the elongated secondary-slat-body 122 may be an exposed surface directed outwards from the shutter curtain 101 (or an outward facing surface). The interior surface 122b of the elongated secondary-slat-body 122 may be directed towards (or facing) the interior space 101c of the shutter curtain 101.

[00040] According to various embodiments, the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 may be made from a sheet of material (e.g. a sheet of metal, a sheet of aluminium, etc.) roll-formed to integrally form the first engagement longitudinal portion 124, the second engagement longitudinal portion 126, and the retaining arrangement 128. According to various embodiments, the sheet of material may be bent inwards with respect to the interior surface 122b of the elongated secondary-slat-body 122 along a first of the two opposite longest sides of the main portion 129 of the elongated secondary-slat-body 122 (for example, to form an angle of about 90° with respect to the main portion 129 of the elongated secondary-slat-body 122) and further bent towards the longitudinal axis of the elongated secondary-slat-body 122 (for example, to form an angle from 90° to 135°) for forming the insert profile of the first engagement longitudinal portion 124 the elongated secondary-slat-body 122 via roll-forming. From the first engagement longitudinal portion 124 of the elongated secondary-slat-body 122, the corresponding first segment of the sheet of material may be aligned to be parallel to the main portion 129 of the elongated secondary-slat-body 122 and folded over or folded back so as to form the first lip formation 128a (or hem-like or pleat-like formation) of the retaining arrangement 128 of the elongated secondary-slat-body 122. According to various embodiments, the sheet of material may be bent inwards with respect to the interior surface 122b of the elongated secondary-slat-body 122 along a second of the two opposite longest sides of the main portion 129 of the elongated secondary-slat-body 122 (for example, to form an angle of about 90° with respect to the main portion 129 of the elongated secondary-slat-body 122), further bent away from the longitudinal axis of the elongated secondary-slat-body 122 (for example, to form an angle from 90° to 135°), bent inward again with respect to the interior surface 122b of the elongated secondary-slat-body 122 (for example, to form an angle from 90° to 135°), and bent towards the longitudinal axis of the elongated secondary-slat-body 122 for forming the recess profile (e.g. a step profile) of the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122 via roll-

forming. From the second engagement longitudinal portion 126 of the elongated secondary-slat-body 122, the corresponding segment of the sheet of material may be aligned to be parallel to the main portion 129 of the elongated secondary-slat-body 122 and folded over or folded back so as to form the second lip formation 128b (or hem-like or pleat-like formation) of the retaining arrangement 128 of the elongated secondary-slat-body 122. Accordingly, the first lip formation 128a and the second lip formation 128b of the retaining arrangement 128 of the elongated secondary-slat-body 122 may be directed or extending towards each other in a manner parallel with the main portion 129 of the elongated secondary-slat-body 122. Accordingly, the first engagement longitudinal portion 124, the second engagement longitudinal portion 126, and the retaining arrangement 128 may be integrally roll-formed from the sheet of material with respect to the main portion 129 of the elongated secondary-slat-body 122.

[00041] According to various embodiments, from the first lip formation 128a of the elongated secondary-slat-body 122, the sheet of material may be bent inwards again with respect to the interior surface 122b (for example, to form an angle of about 90°) so as to be perpendicular to the main portion 129 of the elongated secondary-slat-body 122 for forming the first longitudinal edge portion 125. Accordingly, the first longitudinal edge portion 125 of the elongated secondary-slat-body 122 may be perpendicular to the main portion 129 of the elongated secondary-slat-body 122. Further a fringe 125a of the first longitudinal edge portion 125 of the elongated secondary-slat-body 122 may be angled. According to various embodiments, from the second lip formation 128b, the sheet of material may be bent inwards again with respect to the interior surface 122b of the elongated secondary-slat-body 122 (for example, to form an angle of about 90°) so as to be perpendicular to the main portion 129 of the elongated secondary-slat-body 122 for forming the second longitudinal edge portion 127 of the elongated secondary-slat-body 122. Accordingly, the second longitudinal edge portion 127 of the elongated secondary-slat-body 122 may be perpendicular to the main portion 129 of the elongated secondary-slat-body 122. Further a fringe 127a of the second longitudinal edge portion 127 of the elongated secondary-slat-body 122 may be angled. According to various embodiments, the fringe 125a of the first longitudinal edge portion 125 of the elongated secondary-slat-body 122 and the fringe 127a of the second longitudinal edge portion 127 of the elongated secondary-slat-body 122 may be angled towards each other.

[00042] According to various embodiments, the elongated primary-slat-body 112 of each of the at least two primary slats 110 may include a main portion 119 between the first interlockable longitudinal edge portion 114 of the elongated primary-slat-body 112 and the second interlockable longitudinal edge portion 116 of the elongated primary-slat-body 112.

5 The main portion 119 of the elongated primary-slat-body 112 may be a broadest longitudinal section of the elongated primary-slat-body 112 which may be lined abreast or placed side-by-side with the main portion of the elongated primary-slat-body 112 of an adjacent primary slats 110 so as to form the first side 101a of the shutter curtain 101. Accordingly, the main portions 119 of the at least two primary slats may together form the first side 101a of the
10 shutter curtain 101. According to various embodiments, the main portion 119 of the elongated primary-slat-body 112 may be of a rectangular planar shape or a long rectangular planar shape. Further, the main portion 119 of the elongated primary-slat-body 112 may be between the first interlockable longitudinal edge portion 114 of the elongated primary-slat-body 112 and the second interlockable longitudinal edge portion 116 of the elongated
15 primary-slat-body 112 such that the first interlockable longitudinal edge portion 114 of the elongated primary-slat-body 112 and the second interlockable longitudinal edge portion 116 of the elongated primary-slat-body 112 may respectively be at two opposite longest sides of the main portion 119 of the elongated primary-slat-body 112.

[00043] According to various embodiments, the elongated primary-slat-body 112 of each
20 of the at least two primary slats 110 may further include a retaining arrangement 118. The retaining arrangement 118 of the elongated primary-slat-body 112 may hold the second portion 136 of the rigid thermal-insulating body 132 of a corresponding one of the at least two thermal insulating units 130 to the elongated primary-slat-body 110. According to various embodiments, the retaining arrangement 118 of the elongated primary-slat-body 112
25 may hold, or support, or secure the second portion 136 of the rigid thermal-insulating body 132 to the elongated primary-slat-body 112 so as to keep the rigid thermal-insulating body 132 from falling in order to maintain it in position with respect to the elongated primary-slat-body 112. Hence, the retaining arrangement 118 of the elongated primary-slat-body 112 may hold or support, or secure the second portion 136 of the rigid thermal-insulating body
30 132 in a fixed disposition relative to each other. According to various embodiments, the retaining arrangement 118 of the elongated primary-slat-body 112 may be in direct engagement with the second portion 136 of the rigid thermal-insulating body 132 as shown in FIG. 1A to FIG. 1B. Accordingly, the second portion 136 of the rigid thermal-insulating

body 132 may be in direct contact or abutment with the retaining arrangement 118 of the elongated primary-slat-body 112.

[00044] According to various embodiments, the retaining arrangement 118 of the elongated primary-slat-body 112 may include a pair of opposing lip formations 118a, 118b
 5 extending towards each other respectively from the first interlockable longitudinal edge portion 114 and the second interlockable longitudinal edge portion 116 of the elongated primary-slat-body 112. A first lip formation 118a of the pair may be between the first interlockable longitudinal edge portion 114 and the main portion 119 of the elongated primary-slat-body 112. A second lip formation 118b of the pair may be between the second
 10 interlockable longitudinal edge portion 116 and the main portion 119 of the elongated primary-slat-body 112. The first lip formation 118a may be a protrusion extending away from the first interlockable longitudinal edge portion 114 in a manner parallel to the main portion 119 of the elongated primary-slat-body 112 so as to define a first channel between the first lip formation 118a and the main portion 119 of the elongated primary-slat-body 112.
 15 The second lip formation 118b may be a protrusion extending away from the second interlockable longitudinal edge portion 116 in a manner parallel to the main portion 119 of the elongated primary-slat-body 112 so as to define a second channel between the second lip formation 118b and the main portion 119 of the elongated primary-slat-body 112. Further, the first lip formation 118a and the second lip formation 118b may be extending towards
 20 each other with respect to the main portion 119 of the elongated primary-slat-body 112 such that the first channel and the second channel respectively formed therebetween may be two opposing channels (i.e. directed towards each other or facing each other).

[00045] According to various embodiments, each of the pair of opposing lip formations 118a, 118b of the retaining arrangement 118 of the elongated primary-slat-body 112 may
 25 be formed by folding over a corresponding segment of the elongated primary-slat-body 112. Accordingly, the first lip formation 118a of the retaining arrangement 118 of the elongated primary-slat-body 112 may be formed by folding over a corresponding first segment of the elongated primary-slat-body 112 to form a hem-like or pleat-like formation extending alongside the first interlockable longitudinal edge portion 114. Similarly, the second lip
 30 formation 118b of the retaining arrangement 118 of the elongated primary-slat-body 112 may be formed by folding over a corresponding second segment of the elongated primary-slat-body 112 to form a hem-like or pleat-like formation extending alongside the second interlockable longitudinal edge portion 116. According to various embodiments, each of the

pair of opposing lip formations 118a, 118b of the retaining arrangement 118 of the elongated primary-slat-body 112 may be parallel to the longitudinal axis of the elongated primary-slat-body 112 as well as parallel to the main portion 119 of the elongated primary-slat-body 112.

[00046] According to various embodiments, the second portion 136 of the rigid thermal-insulating body 132 of each of the at least two thermal insulating units 130 may include an engagement arrangement 137 for coupling the second portion 136 of the rigid thermal-insulating body 132 to the elongated primary-slat-body 112 of a corresponding primary slat 110 of the at least two primary slats. Accordingly, the engagement arrangement 137 of the second portion 136 of the rigid thermal-insulating arrangement 137 may engage with the retaining arrangement 118 of the elongated primary-slat-body 112 to couple the second portion 136 of the rigid thermal-insulating arrangement 137 to the elongated primary-slat-body 112. According to various embodiments, the engagement arrangement 137 of the second portion 136 of the rigid thermal-insulating body 132 may include a profile complementary to the retaining arrangement 118 of the elongated primary-slat-body 112 to facilitate engagement and coupling. Hence, depending on the configuration of the retaining arrangement 118 of the elongated primary-slat-body 112, the engagement arrangement 137 of the second portion 136 of the rigid thermal-insulating body 132 may be configured accordingly.

[00047] Referring to FIG. 1A and FIG. 1B, according to various embodiments, when the retaining arrangement 118 of the elongated primary-slat-body 112 includes the pair of opposing lip formations 118a, 118b, the engagement arrangement 137 of the second portion 136 of the rigid thermal-insulating body 132 may include a pair of transverse protrusions 137a, 137b. According to various embodiments, the pair of transverse protrusions 137a, 137b may be extending in opposite directions with respect to the rigid thermal-insulating body 132. Accordingly, the pair of transverse protrusions 137a, 137b may be extending sideways or laterally from the rigid thermal-insulating body 132. According to various embodiments, the pair of transverse protrusions 137a, 137b of the second portion 136 of the rigid thermal-insulating body 132 may be in engagement with the pair of opposing lip formations 118a, 118b of the retaining arrangement 118 of the elongated primary-slat-body 112 of a corresponding primary slat 110 for connecting the second portion 136 of the rigid thermal-insulating body 132 to the elongated primary-slat-body 112. According to various embodiments, the first transverse protrusion 137a of the pair may be inserted into the first channel formed between the first lip formation 118a of the retaining arrangement 118 of the

elongated primary-slat-body 112 and the main portion 119 of the elongated primary-slat-body 112, and the second transverse protrusion 137b of the pair may be inserted into the second channel formed between the second lip formation 118b of the retaining arrangement 118 of the elongated primary-slat-body 112 and the main portion 119 of the elongated primary-slat-body 112. Accordingly, the retaining arrangement 118 and the main portion 119 of the elongated primary-slat-body 112 may cooperatively retain or hold or secure the pair of transverse protrusions 137a, 137b of the second portion 136 of the rigid thermal-insulating body 132 to keep or maintain the rigid thermal-insulating body 132 in the fixed disposition with respect to the elongated primary-slat-body 112.

10 **[00048]** According to various embodiments, the elongated primary-slat-body 112 of each of the at least two secondary slats 110 may be made from a sheet of material (e.g. a sheet of metal, a sheet of aluminium, etc.) roll-formed to integrally form the first interlockable longitudinal edge portion 114, the second interlockable longitudinal edge portion 116, and the retaining arrangement 118. According to various embodiments, the sheet of material
15 may be bent, via roll-forming, inwards with respect to the interior surface 112b of the elongated primary-slat-body 112 along a first of the two opposite longest sides of the main portion 119 of the elongated primary-slat-body 112 and towards the longitudinal axis of the the elongated primary-slat-body 112) for aligning the corresponding first segment of the sheet of material parallel to the main portion 119 of the elongated primary-slat-body 112
20 and/or to form the first channel. Further, the corresponding first segment may be folded over or folded back, via roll-forming, so as to form the first lip formation 118a (or hem-like or pleat-like formation) of the retaining arrangement 118 of the elongated primary-slat-body 112. According to various embodiments, the sheet of material may be bent, via roll-forming, inwards with respect to the interior surface 112b of the elongated primary-slat-body 112
25 along a second of the two opposite longest sides of the main portion 119 of the elongated primary-slat-body 112 and towards the longitudinal axis of the elongated primary-slat-body 112 for aligning the corresponding second segment of the sheet of material parallel to the main portion 119 of the elongated primary-slat-body 112 and/or to form the second channel. Further, the corresponding second segment may be folded over or folded back, via roll-
30 forming, so as to form the second lip formation 118b (or hem-like or pleat-like formation) of the retaining arrangement 118 of the elongated primary-slat-body 112. Accordingly, the first lip formation 118a and the second lip formation 118b of the retaining arrangement 118 of the elongated primary-slat-body 112 may be directed or extending towards each other in

a manner parallel with the main portion 119 of the elongated primary-slat-body 112. Accordingly, the retaining arrangement 118 of the elongated primary-slat-body 112 may be integrally roll-formed from the sheet of material with respect to the main portion 119 of the elongated primary-slat-body 112.

5 **[00049]** According to various embodiments, from the first lip formation 118a of the elongated primary-slat-body 112, the sheet of material may be curled inwards, via roll-forming, with respect to the interior surface 112b of the elongated primary-slat-body 112 and towards the longitudinal axis of the elongated primary-slat-body 112 to form the inward curl portion serving as the first interlockable longitudinal edge portion 114 of the elongated
10 primary-slat-body 112. According to various embodiments, from the second lip formation 118b of the elongated primary-slat-body 112, the sheet of material may be curled outwards, via roll-forming, with respect to the exterior surface 112a of the elongated primary-slat-body 112 and towards the longitudinal axis of the elongated primary-slat-body 112 to form the outward curl portion serving as the second interlockable longitudinal edge portion 116
15 of the elongated primary-slat-body 112. Accordingly, the first interlockable longitudinal edge portion 114, the second interlockable longitudinal edge portion 116, and the retaining arrangement 118 of the elongated primary-slat-body 112 may be integrally roll-formed from the sheet of material with respect to the main portion 119 of the elongated primary-slat-body 112.

20 **[00050]** Referring to FIG. 1C and FIG. 1D, according to various embodiments, the primary slat 110, the secondary slat 120 and the thermal insulating unit 130 may be assembled together by sliding the thermal insulating unit 130 with respect to the primary slat 110 and the secondary slat 120 in a manner such that the engagement arrangement 135 of the first portion 134 of the rigid thermal-insulating body 132 may engage with the
25 retaining arrangement 128 of the elongated secondary-slat-body 122 and the engagement arrangement 137 of the second portion 136 of the rigid thermal-insulating body 132 may engage with the retaining arrangement 118 of the elongated primary-slat-body 112. According to various embodiments, two or more thermal insulating units 130 may couple the primary slat 110 to the secondary slat 120 as shown in FIG. 1D and FIG. 1E.

30 **[00051]** According to various embodiments, the shutter curtain 101 may further include insulating material 140 inserted between each of the at least two primary slats 110 and the corresponding one of the at least two secondary slats 120. According to various embodiments, the insulating material 140 may be disposed to fill up remaining spaces,

unoccupied by a corresponding one of the at least two thermal insulating units 130, between said primary slat 110 and said secondary slat 120. According to various embodiments, the insulating material 140 may be non-rigid insulating material. According to various embodiments, the non-rigid insulating material may include, but not limited to, mineral wool, fiberglass, cellulose, polystyrene, polyurethane foam, etc.

[00052] According to various embodiments, the first longitudinal edge portion 125 and the second longitudinal edge portion 127 of the elongated secondary-slat-body 122 of each of the at least two secondary slats may serve as auxiliary retaining arrangement 142 for keeping the insulating material 140 in place. Accordingly, the auxiliary retaining arrangement 142 may act as a barrier to prevent the insulating material 140 from easily falling out after being inserted between each of the at least two primary slats 110 and the corresponding one of the at least two secondary slats 120. According to various embodiments, the insulating material 140 may be inserted in a manner so as to abut against or contact the auxiliary retaining arrangement 142 such that the auxiliary retaining arrangement 142 may obstruct or block the insulating material 140 from falling out. According to various embodiments, the the first longitudinal edge portion 125 and the second longitudinal edge portion 127 of the elongated secondary-slat-body 122, which are serving as the auxiliary retaining arrangement 142, may be extending perpendicularly with respect to the main portion 129 of the elongated secondary-slat-body 122 of said secondary slat 120 the auxiliary retaining arrangement 142, and, hence, may be effective in obstructing or blocking the insulating material 140. Furthermore, the angled fringe 125a of the first longitudinal edge portion 125 and the angled fringe 127a of the second longitudinal edge portion 127 may additionally serve as a catch or hook to cling on to the insulating material 140 so as to provide further resistance for the insulating material 140 to fall out.

[00053] FIG. 2 shows a roller shutter 100 with the shutter curtain 101 according to various embodiments. According to various embodiments, the roller shutter 100 may include a drum 105 and the shutter curtain 101 may be rolled on and rolled off the drum 105. According to various embodiments, a terminal end of the shutter curtain 101 may be attached to the drum 105 such that rotating the drum 105 may roll the shutter curtain 101 on the drum 105 or roll the shutter curtain 101 off the drum 105. Further, the shutter curtain 101 may be attached to the drum 105 in a manner such that the at least two primary slats 110 and the at least two secondary slats 120 may be parallel to a rotational axis of the drum 105. According to various embodiments, the shutter curtain 101 may be oriented such that the at least two

primary slats 110 of the shutter curtain 101 may be directed towards the drum 105 and the at least two secondary slats 120 of the shutter curtain 101 may be directed away from the drum 105 when the shutter curtain is wound round the drum 105. According to various embodiments, the drum 105 of the roller shutter 100 may be installed or mounted to a door head 106. Further, the roller shutter 100 may include guide rails 108 installed or mounted to side casings or side walls. The guide rails 108 may serve to guide the shutter curtain 101 during rolling out (i.e. deployment) or rolling in (i.e. retraction).

[00054] FIG. 3A shows a shutter curtain 301 according to various embodiments, and FIG. 3B shows two links of the shutter curtain 301 of FIG. 1A pivoted with respect to each other according to various embodiments. FIG. 3C shows a disassembled view of a link of the shutter curtain 301 of FIG. 3A according to various embodiments. FIG. 3D shows an assembled view of a link of the shutter curtain 301 of FIG. 3A according to various embodiments. FIG. 3E shows a front view of the link of FIG. 3D according to various embodiments.

[00055] According to various embodiments, the shutter curtain 301 may contain any one or more or a combination of or all the parts and/or features and/or limitations of the shutter curtain 101 as described with reference to FIG. 1A and FIG. 1B. In the following, the shutter curtain 301 is described with like reference characters generally referring to the same or corresponding parts/features/limitations of the shutter curtain 101 of FIG. 1A and FIG. 1B. The description of the parts/features/limitations made with respect to the shutter curtain 101 of FIG. 1A and FIG. 1B are also applicable with respect to corresponding parts/features/limitations of the shutter curtain 301, and vice versa.

[00056] According to various embodiments, for example as shown in FIG. 3A and FIG. 3B, the shutter curtain 301 may include the at least two primary slats 110 and the at least two secondary slats 120, which may be the same or identical with the at least two primary slats 110 and the at least two secondary slats 120 of the shutter curtain 101 of FIG. 1A and FIG. 1B. Accordingly, all descriptions, changes, modifications, and variations that are applicable to the at least two primary slats 110 and/or the at least two secondary slats 120 of the shutter curtain 101 of FIG. 1A and FIG. 1B are also applicable to the at least two primary slats 110 and the at least two secondary slats 120 of the shutter curtain 301.

[00057] According to various embodiments, the shutter curtain 301 may, similar to the shutter curtain 101 of FIG. 1A and FIG. 1B, include at least two thermal insulating units 330. The at least two thermal insulating units 330 of the shutter curtain 301 may, similar to

the at least two thermal insulating units 130 of the shutter curtain 101 of FIG. 1A and FIG. 1B, be connected between the at least two primary slats 110 and the at least two secondary slats 120 of the shutter curtain 301 to hold apart each of the at least two primary slats 110 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 301 in a manner so as to thermally insulate (e.g. thermally separate) said primary slat 110 from said secondary slat 120. Accordingly, the at least two thermal insulating unit 330 of the shutter curtain 301 may thermally insulate (e.g. thermally separate) each of the at least two primary slats 110 of the shutter curtain 301 from the corresponding one of the at least two secondary slats 120 of the shutter curtain 301. In other words, each of the at least two thermal insulating units 330 of the shutter curtain 301 may be connected between one of the at least two primary slats 110 of the shutter curtain 301 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 301 to hold apart said primary slat 110 and said secondary slat 120 in a manner so as to thermally insulate (e.g. thermally separate) said primary slat 110 from said secondary slat 120. For example, the first primary slat 110a of the at least two primary slats 110 of the shutter curtain 301 and a first secondary slat 120a of the at least two secondary slats 120 of the shutter curtain 301 may be held apart by a first thermal insulating unit 330a of the at least to two thermal insulating units 330 of the shutter curtain 301 to thermally insulate (e.g. thermally separate) the first primary slat 110a of the shutter curtain 301 and the first secondary slat 120a of the shutter curtain 301. Similarly, the second primary slat 110b of the at least two primary slats 110 of the shutter curtain 301 and a second secondary slat 120b of the at least two secondary slats 120 of the shutter curtain 301 may be held apart by a second thermal insulating unit 330b of the at least to two thermal insulating units 330 of the shutter curtain 301 to thermally insulate (e.g. thermally separate) the second primary slat 110b of the shutter curtain 301 and the second secondary slat 120b of the shutter curtain 301.

[00058] According to various embodiments, similar to the shutter curtain 101 of FIG. 1A and FIG. 1B, each of the at least two primary slats 110 of the shutter curtain 301 may be coupled to one portion (e.g. a first portion 334) of a corresponding thermal insulating unit 330 of the shutter curtain 301, and a corresponding one of the at least two secondary slats 120 of the shutter curtain 301 may be coupled to another portion (e.g. a second portion 336) of the corresponding thermal insulating unit 330 of the shutter curtain 301. According to various embodiments, said thermal insulating unit 330 may thermally separate said primary slat 110 of the shutter curtain 301 and said corresponding secondary slat 120 of the shutter

curtain 301 in a manner such that said primary slat 110 of the shutter curtain 301 may not be in any direct contact with said corresponding secondary slat 120 of the shutter curtain 301. Further, said thermal insulating unit 330 of the shutter curtain 301 may be connected between said primary slat 110 of the shutter curtain 301 and said second slat 120 of the shutter curtain 301 without any other thermal conductive component connected therebetween. Thus, said primary slat 110 of the shutter curtain 301 and said second slat 120 of the shutter curtain 301 may be free of any direct heat conduction path or “thermal bridge” therebetween. Therefore, said thermal insulating unit 330 of the shutter curtain 301 may serve to break or isolate or cut thermal conduction between said primary slat 110 of the shutter curtain 301 and said secondary slat 120 of the shutter curtain 301. Hence, the thermal insulation integrity between said primary slat 110 of the shutter curtain 301 and said secondary slat 120 of the shutter curtain 301 may be preserved and said thermal insulating unit 330 of the shutter curtain 301 may effectively thermally insulate (e.g. thermally separate) said primary slat 110 of the shutter curtain 301 from said secondary slat 120 of the shutter curtain 301, and vice versa.

[00059] Similar to the shutter curtain 101 of FIG. 1A and FIG. 1B, with the at least two thermal insulating unit 330 of the shutter curtain 301 thermally insulating (e.g. thermally separating) the at least two secondary slats 120 of the shutter curtain 301 and the at least two primary slats 110 of the shutter curtain 301, a first side 301a (formed by the at least two primary slats) and a second side 301b (formed by the at least two secondary slats) of the shutter curtain 301 may be thermally insulated (e.g. thermally separated) from each other via the at least two thermal insulating unit 330 of the shutter curtain 301. According to various embodiments, the shutter curtain 301 may provide a simple and sleek configuration with thermal insulation capability, whereby the at least two primary slats 110 of the shutter curtain 301 may form the continuous and seamless first side 301a of the shutter curtain 301, the at least two secondary slats 120 of the shutter curtain 301 may form the second side 301b of the shutter curtain 301, and the at least two thermal insulating unit 330 of the shutter curtain 301 may thermally insulate (e.g. thermally separate) the first side 301a and the second side 301b of the shutter curtain 301, without requiring additional components to join the slats together or to insulate the first side and the second side.

[00060] According to various embodiments, similar to the shutter curtain 101 of FIG. 1A and FIG. 1B, each of the at least two thermal insulating unit 330 of the shutter curtain 301 may include a rigid thermal-insulating-body 332. The rigid thermal-insulating body 332

may include the first portion 334 and the second portion 336, wherein the first portion 334 and the second portion 336 are opposite portions of the rigid thermal-insulating body 332. The rigid thermal-insulating body 332 may be stiff or unyielding or non-pliant or non-flexible such that the rigid thermal-insulating body 332 may firmly hold a corresponding one of the at least two primary slats 110 of the shutter curtain 301 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 301 in a fixed disposition relative to each other. Accordingly, the rigid thermal-insulating body 332 may have a rigidity or stiffness to fixedly hold said primary slat 110 of the shutter curtain 301 and said secondary slat 120 of the shutter curtain 301 in a manner such that said primary slat 110 of the shutter curtain 301 and said secondary slat 120 of the shutter curtain 301 may be immovable relative to each other. Hence said primary slat 110 of the shutter curtain 301 and said secondary slat 120 of the shutter curtain 301 may be held in place in the fixed disposition relative to each other by the rigid thermal-insulating body 332. According to various embodiments, the rigid thermal-insulating body 332 may include a slab or panel or block of rigid solid thermal-insulating material including, but not limited to, wood, ceramic, plastic, glass, or carbon. According to various embodiments, the rigid thermal-insulating body 332 may include, but not limited to a rigid solid structure/shape, a rigid lattice structure/shape, or a rigid frame structure/shape. According to various embodiments, the rigid thermal-insulating body 332 may include, but not limited to, a rigid composite assembly such as a sandwich-structured composite, or a rigid composite material such as fibre-reinforced plastic or glass-reinforced plastic. According to various embodiments, when the rigid thermal-insulating body 332 is a rigid composite assembly or a rigid composite material, the rigid thermal-insulating body 332 may include one or a combination of thermal-insulating material including, but not limited to, wood, ceramic, plastic, glass, carbon, mineral wool, fiberglass, cellulose, polystyrene, polyurethane foam, etc.

[00061] According to various embodiments, the elongated secondary-slat-body 122 of each of the at least two secondary slats 120 of the shutter curtain 301 may, similar to that of the shutter curtain 101 of FIG. 1A and FIG. 1B, further include the retaining arrangement 128. However, in the shutter curtain 301, the retaining arrangement 128 of the elongated secondary-slat-body 122 may indirectly hold the first portion 334 of the rigid thermal-insulating body 332 of a corresponding one of the at least two thermal insulating units 330 of the shutter curtain 301 to the elongated secondary-slat-body 120 via a secondary-slat-support-frame 360 coupled to the retaining arrangement 128 of the elongated secondary-

slat-body 122. According to various embodiments, the retaining arrangement 128 of the elongated secondary-slat-body 122 may indirectly hold, or support, or secure the first portion 334 of the rigid thermal-insulating body 332 to the elongated secondary-slat-body 122, via the secondary-slat-support-frame 360, so as to keep the rigid thermal-insulating body 332 from falling in order to maintain it in position with respect to the elongated secondary-slat-body 122. Hence, the retaining arrangement 128 of the elongated secondary-slat-body 122 may indirectly hold or support, or secure the first portion 334 of the rigid thermal-insulating body 332, via the secondary-slat-support-frame 360, in a fixed disposition relative to each other. According to various embodiments, the retaining arrangement 128 of the elongated secondary-slat-body 122 may be indirectly engaged with the first portion 334 of the rigid thermal-insulating body 332 as shown in FIG. 3A to FIG. 3B.

[00062] According to various embodiments, each of the at least two secondary slats 120 of the shutter curtain 301 may further include the secondary-slat-support-frame 360 coupled to the elongated secondary-slat-body 122. The secondary-slat-support-frame 360 may be coupled to the retaining arrangement 128 of the elongated secondary-slat-body 122. Accordingly, the retaining arrangement 128 of the elongated secondary-slat-body 122 may hold the secondary-slat-support-frame 360 to the elongated secondary-slat-body 120. According to various embodiments, the retaining arrangement 128 of the elongated secondary-slat-body 122 may hold, or support, or secure the secondary-slat-support-frame 360 so as to keep the secondary-slat-support-frame 360 in position with respect to the elongated secondary-slat-body 122. Hence, the retaining arrangement 128 of the elongated secondary-slat-body 122 may hold or support, or secure the secondary-slat-support-frame 360 to the elongated secondary-slat-body 122 in a fixed disposition relative to each other. According to various embodiments, the retaining arrangement 128 of the elongated secondary-slat-body 122 may be in direct engagement with the secondary-slat-support-frame 360 as shown in FIG. 3A to FIG. 3B.

[00063] According to various embodiments, the secondary-slat-support-frame 360 may include an attachment arrangement 362 for coupling the secondary-slat-support-frame 360 to the elongated secondary-slat-body 122. Accordingly, the attachment arrangement 362 of the secondary-slat-support-frame 360 may engage with the retaining arrangement 128 of the elongated secondary-slat-body 122 to couple the secondary-slat-support-frame 360 to the elongated secondary-slat-body 122. According to various embodiments, the attachment

arrangement 362 of the secondary-slat-support-frame 360 may be complementary to the retaining arrangement 128 of the elongated secondary-slat-body 122 to facilitate engagement and coupling. Hence, depending on the configuration of the retaining arrangement 128 of the elongated secondary-slat-body 122, the attachment arrangement 362 of the secondary-slat-support-frame 360 may be configured accordingly.

[00064] According to various embodiments, when the retaining arrangement 128 of the elongated secondary-slat-body 122 includes the pair of opposing lip formations 128a, 128b, the attachment arrangement 362 of the secondary-slat-support-frame 360 may include a pair of grooves 362a, 362b. According to various embodiments, the pair of grooves 362a, 362b may be directed away from each other along two opposite edge portions 364, 366 of the secondary-slat-support-frame 360. Accordingly, a groove-face of a first groove 362a of the pair of grooves and a groove-face of a second groove 362b of the pair of grooves may be directed or facing in opposite directions or away from each other. Hence, the pair of grooves 362a, 362b may be respectively directed outwards from the two opposite edge portions 364, 366 of the secondary-slat-support-frame 360. According to various embodiments, the secondary-slat-support-frame 360 may be coupled to the elongated secondary-slat-body 122 with the pair of grooves 362a, 362b of the secondary-slat-support-frame 360 respectively slide over the pair of opposing lip formations 128a, 128b of the elongated secondary-slat-body 122.

[00065] According to various embodiments, the secondary-slat-support-frame 360 may include a recess portion 368 between the two opposite edge portions 364, 366 of the secondary-slat-support-frame 360. Accordingly, the two opposite edge portions 364, 366 of the secondary-slat-support-frame 360 may respectively be on opposite sides of the recess portion 368 of the secondary-slat-support-frame 360. Hence, the pair of grooves 362a, 362b may be respectively be on opposite sides of the recess portion 368 of the secondary-slat-support-frame 360, and may be directed outwards and away from each other with respect to the recess portion 368 of the secondary-slat-support-frame 360. According to various embodiments, the recess portion 368 may be at a middle region of the secondary-slat-support-frame 360 with respect to the two opposite edge portions 364, 366 of the secondary-slat-support-frame 360. Accordingly, the two opposite edge portions 364, 366 of the secondary-slat-support-frame 360 (and/or the pair of grooves 362a, 362b of the secondary-slat-support-frame 360) may be equidistant from the recess portion 368 of the secondary-slat-support-frame 360.

[00066] According to various embodiments, the recess portion 368 of the secondary-slat-support-frame 360 may hold the first portion 334 of the rigid thermal-insulating body 332 to the secondary-slat-support-frame 360 for coupling the rigid thermal-insulating body 332 to the elongated secondary-slat-body 122. According to various embodiments, the recess portion 368 of the secondary-slat-support-frame 360 may hold, or support, or secure the first portion 334 of the rigid thermal-insulating body 332 to the secondary-slat-support-frame 360 so as to keep the rigid thermal-insulating body 332 from falling in order to maintain it in position with respect to the secondary-slat-support-frame 360 and/or the elongated secondary-slat-body 122. Hence, the recess portion 368 of the secondary-slat-support-frame 360 may hold or support, or secure the first portion 334 of the rigid thermal-insulating body 332 in a fixed disposition relative to each other. According to various embodiments, the recess portion 368 of the secondary-slat-support-frame 360 may be in direct engagement with the first portion 334 of the rigid thermal-insulating body 332 as shown in FIG. 3A to FIG. 3B. Accordingly, the first portion 334 of the rigid thermal-insulating body 332 may be in direct contact or abutment with the recess portion 368 of the secondary-slat-support-frame 360.

[00067] According to various embodiments, the first portion 334 of the rigid thermal-insulating body 332 may be inserted into the recess portion 368 of the secondary-slat-support-frame 360 and be retained in the recess portion 368 of the secondary-slat-support-frame 360. According to various embodiments, the first portion 334 of the rigid thermal-insulating body 332 of each of the at least two thermal insulating units 330 of the shutter curtain 301 may include an engagement arrangement 335 for coupling the first portion 334 of the rigid thermal-insulating body 332 to the recess portion 368 of the secondary-slat-support-frame 360. According to various embodiments, the engagement arrangement 335 of the first portion 334 of the rigid thermal-insulating body 332 may include a profile complementary to the recess portion 368 of the secondary-slat-support-frame 360 to facilitate engagement and coupling. Hence, depending on the configuration of the recess portion 368 of the secondary-slat-support-frame 360, the engagement arrangement 335 of the first portion 334 of the rigid thermal-insulating body 332 may be configured accordingly. According to various embodiments, the recess portion 368 of the secondary-slat-support-frame 360 may hold the first portion 334 of the rigid thermal-insulating body 332 via interference fit or friction or fastening means. The fastening means may include, but not limited to, adhesive, snap-fit, snap-fastener, rivet, bolt and nut, screw, pin, nail, latch, catch,

or clamp. Accordingly, the engagement arrangement 335 of the first portion 334 of the rigid thermal-insulating body 332 may be configured accordingly to have a complementing shape, dimensions, texture, and/or fastening elements.

[00068] According to various embodiments, the secondary-slat-support-frame 360 of each of the at least two secondary slats 120 may be made from a sheet of material (e.g. a sheet of metal, a sheet of aluminium, etc.) roll-formed to integrally form the attachment arrangement 362 and the recess portion 368 of the secondary-slat-support-frame 360. According to various embodiments, the pair of grooves 362a, 362b of the attachment arrangement 362 along the two opposite edge portions 364, 366 of the secondary-slat-support-frame 360 and the recess portion 368 of the secondary-slat-support-frame 360 may be integrally formed by roll-forming the sheet of material. According to various embodiments, a region of the sheet of material between the two opposite edge portions 364, 366 may be bent, via roll-forming, to form an open channel defining the recess portion 368 of the secondary-slat-support-frame 360. According to various embodiments, the open channel (or the recess portion 368 of the secondary-slat-support-frame 360) may be of a shape resembling a hat channel, a furring channel, or a U-shaped channel. According to various embodiments, the two opposite edge portions 364, 366 of the sheet of material may be bent, via roll-forming, to form the pair of grooves 362a, 362b of the attachment arrangement 362 of the secondary-slat-support-frame 360. According to various embodiments, the two opposite edge portions 364, 366 may be respectively bent to fold over or fold back so as to form a hem-like or pleat-like formation, and further formed a U-shaped channel with respective edges of the sheet of material curled from the hem-like or pleat-like formation to define the pair of grooves 362a, 362b. Accordingly, the groove-faces of the pair of grooves 362a, 362b may be respectively directed outwards from the two opposite edge portions 364, 366 of the secondary-slat-support-frame 360.

[00069] According to various embodiments, the elongated primary-slat-body 112 of each of the at least two primary slats 110 of the shutter curtain 301 may, similar to that of the shutter curtain 101 of FIG. 1A and FIG. 1B, further include the retaining arrangement 118. However, in the shutter curtain 301, the retaining arrangement 118 of the elongated primary-slat-body 112 may indirectly hold the second portion 336 of the rigid thermal-insulating body 332 of a corresponding one of the at least two thermal insulating units 330 of the shutter curtain 301 to the elongated primary-slat-body 112 via a primary-slat-support-frame 350 coupled to the retaining arrangement 118 of the elongated primary-slat-body 112.

According to various embodiments, the retaining arrangement 118 of the elongated primary-slat-body 112 may indirectly hold, or support, or secure the second portion 336 of the rigid thermal-insulating body 332 to the elongated primary-slat-body 112, via the primary-slat-support-frame 350, so as to keep the rigid thermal-insulating body 332 from falling in order to maintain it in position with respect to the elongated primary-slat-body 112. Hence, the retaining arrangement 118 of the elongated primary-slat-body 112 may indirectly hold or support, or secure the second portion 336 of the rigid thermal-insulating body 332, via the primary-slat-support-frame 350, in a fixed disposition relative to each other. According to various embodiments, the retaining arrangement 118 of the elongated primary-slat-body 112 may be indirectly engaged with the second portion 336 of the rigid thermal-insulating body 332 as shown in FIG. 3A to FIG. 3B.

[00070] According to various embodiments, each of the at least two primary slats 110 of the shutter curtain 301 may further include the primary-slat-support-frame 350 coupled to the elongated primary-slat-body 112. The primary-slat-support-frame 350 may be coupled to the retaining arrangement 118 of the elongated primary-slat-body 112. Accordingly, the retaining arrangement 118 of the elongated primary-slat-body 112 may hold the primary-slat-support-frame 350 to the elongated primary-slat-body 110. According to various embodiments, the retaining arrangement 118 of the elongated primary-slat-body 112 may hold, or support, or secure the primary-slat-support-frame 350 so as to keep the primary-slat-support-frame 350 in position with respect to the elongated primary-slat-body 112. Hence, the retaining arrangement 118 of the elongated primary-slat-body 112 may hold or support, or secure the primary-slat-support-frame 350 to the elongated primary-slat-body 112 in a fixed disposition relative to each other. According to various embodiments, the retaining arrangement 118 of the elongated primary-slat-body 112 may be in direct engagement with the primary-slat-support-frame 350 as shown in FIG. 3A to FIG. 3B.

[00071] According to various embodiments, the primary-slat-support-frame 350 may include an attachment arrangement 352 for coupling the primary-slat-support-frame 350 to the elongated primary-slat-body 112. Accordingly, the attachment arrangement 352 of the primary-slat-support-frame 350 may engage with the retaining arrangement 118 of the elongated primary-slat-body 112 to couple the primary-slat-support-frame 350 to the elongated primary-slat-body 112. According to various embodiments, the attachment arrangement 352 of the primary-slat-support-frame 350 may be complementary to the retaining arrangement 118 of the elongated primary-slat-body 112 to facilitate engagement

and coupling. Hence, depending on the configuration of the retaining arrangement 118 of the elongated primary-slat-body 112, the attachment arrangement 352 of the primary-slat-support-frame 350 may be configured accordingly.

[00072] According to various embodiments, when the retaining arrangement 118 of the elongated primary-slat-body 112 includes the pair of opposing lip formations 118a, 118b, the attachment arrangement 352 of the primary-slat-support-frame 350 may include a pair of grooves 352a, 352b. According to various embodiments, the pair of grooves 352a, 352b may be directed away from each other along two opposite edge portions 354, 356 of the primary-slat-support-frame 350. Accordingly, a groove-face of a first groove 352a of the pair of grooves and a groove-face of a second groove 352b of the pair of grooves may be directed or facing in opposite directions or away from each other. Hence, the pair of grooves 352a, 352b may be respectively directed outwards from the two opposite edge portions 354, 356 of the primary-slat-support-frame 350. According to various embodiments, the primary-slat-support-frame 350 may be coupled to the elongated primary-slat-body 112 with the pair of grooves 352a, 352b of the primary-slat-support-frame 350 respectively slide over the pair of opposing lip formations 118a, 118b of the elongated primary-slat-body 112.

[00073] According to various embodiments, the primary-slat-support-frame 350 may include a recess portion 358 between the two opposite edge portions 354, 356 of the primary-slat-support-frame 350. Accordingly, the two opposite edge portions 354, 356 of the primary-slat-support-frame 350 may respectively be on opposite sides of the recess portion 358 of the primary-slat-support-frame 350. Hence, the pair of grooves 352a, 352b may be respectively on opposite sides of the recess portion 358 of the primary-slat-support-frame 350, and may be directed outwards and away from each other with respect to the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the recess portion 358 may be at a middle region of the primary-slat-support-frame 350 with respect to the two opposite edge portions 354, 356 of the primary-slat-support-frame 350. Accordingly, the two opposite edge portions 354, 356 of the primary-slat-support-frame 350 (and/or the pair of grooves 352a, 352b of the primary-slat-support-frame 350) may be equidistant from the recess portion 358 of the primary-slat-support-frame 350.

[00074] According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may hold the second portion 336 of the rigid thermal-insulating body 332 to the primary-slat-support-frame 350 for coupling the rigid thermal-insulating body

332 to the elongated primary-slat-body 112. According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may hold, or support, or secure the second portion 336 of the rigid thermal-insulating body 332 to the primary-slat-support-frame 350 so as to keep the rigid thermal-insulating body 332 from falling in order to maintain it in position with respect to the primary-slat-support-frame 350 and/or the elongated primary-slat-body 112. Hence, the recess portion 358 of the primary-slat-support-frame 350 may hold or support, or secure the second portion 336 of the rigid thermal-insulating body 332 in a fixed disposition relative to each other. According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may be in direct engagement with the second portion 336 of the rigid thermal-insulating body 332 as shown in FIG. 3A to FIG. 3B. Accordingly, the second portion 336 of the rigid thermal-insulating body 332 may be in direct contact or abutment with the recess portion 358 of the primary-slat-support-frame 350.

[00075] According to various embodiments, the second portion 336 of the rigid thermal-insulating body 332 may be inserted into the recess portion 358 of the primary-slat-support-frame 350 and be retained in the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the second portion 336 of the rigid thermal-insulating body 332 of each of the at least two thermal insulating units 330 of the shutter curtain 301 may include an engagement arrangement 337 for coupling the second portion 336 of the rigid thermal-insulating body 332 to the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the engagement arrangement 337 of the second portion 336 of the rigid thermal-insulating body 332 may include a profile complementary to the recess portion 358 of the primary-slat-support-frame 350 to facilitate engagement and coupling. Hence, depending on the configuration of the recess portion 358 of the primary-slat-support-frame 350, the engagement arrangement 337 of the second portion 336 of the rigid thermal-insulating body 332 may be configured accordingly. According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may hold the second portion 336 of the rigid thermal-insulating body 332 via interference fit or friction or fastening means. The fastening means may include, but not limited to, adhesive, snap-fit, snap-fastener, rivet, bolt and nut, screw, pin, nail, latch, catch, or clamp. Accordingly, the engagement arrangement 337 of the second portion 336 of the rigid thermal-insulating body 332 may be configured accordingly to have a complementing shape, dimensions, texture, and/or fastening elements.

[00076] According to various embodiments, the primary-slat-support-frame 350 of each of the at least two primary slats 110 may be made from a sheet of material (e.g. a sheet of metal, a sheet of aluminium, etc.) roll-formed to integrally form the attachment arrangement 352 and the recess portion 358 of the primary-slat-support-frame 350. According to various
5 embodiments, the pair of grooves 352a, 352b of the attachment arrangement 352 along the two opposite edge portions 354, 356 of the primary-slat-support-frame 350 and the recess portion 358 of the primary-slat-support-frame 350 may be integrally formed by roll-forming the sheet of material. According to various embodiments, a region of the sheet of material between the two opposite edge portions 354, 356 may be bent, via roll-forming, to form an
10 open channel defining the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the open channel (or the recess portion 358 of the primary-slat-support-frame 350) may be of a shape resembling a hat channel, a furring channel, or a U-shaped channel. According to various embodiments, the two opposite edge portions 354, 356 of the sheet of material may be bent, via roll-forming, to form the pair of
15 grooves 352a, 352b of the attachment arrangement 352 of the primary-slat-support-frame 350. According to various embodiments, the two opposite edge portions 354, 356 may be respectively bent to fold over or fold back so as to form a hem-like or pleat-like formation, and further formed a U-shaped channel with respective edges of the sheet of material curled from the hem-like or pleat-like formation to define the pair of grooves 352a, 352b.
20 Accordingly, the groove-faces of the pair of grooves 352a, 352b may be respectively directed outwards from the two opposite edge portions 354, 356 of the primary-slat-support-frame 350.

[00077] FIG. 3F shows a disassembled view of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 330 according to various
25 embodiments. FIG. 3G shows an assembled view of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 330 according to various embodiments. According to various embodiments, the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 330 may be assembled together to form an intermediate assembly 370 in a manner whereby the engagement
30 arrangement 335 of the first portion 334 of the rigid thermal-insulating body 332 may be coupled to the recess portion 368 of the secondary-slat-support-frame 360 and the engagement arrangement 337 of the second portion 335 of the rigid thermal-insulating body 332 may be coupled to the recess portion 358 of the primary-slat-support-frame 350.

According to various embodiments, the engagement arrangement 335 of the first portion 334 of the rigid thermal-insulating body 332 may be fitted into the recess portion 368 of the secondary-slat-support-frame 360 and fastened together, for example via a first set of one or more screws 372. According to various embodiments, the engagement arrangement 337
 5 of the second portion 335 of the rigid thermal-insulating body 332 may be fitted to the recess portion 358 of the primary-slat-support-frame 350 and fastened together, for example via a second set of one or more screws 374. According to various embodiments, the first set of one or more screws 372 and the second set of one or more screws 374 may be arranged in a manner so as to be offset from each other to prevent or avoid contact or abutment within the
 10 rigid thermal-insulating body 332.

[00078] Referring to FIG. 3C and FIG. 3D, according to various embodiments, the primary slat 110, the secondary slat 120 and the thermal insulating unit 330 may be assembled together by sliding the intermediate assembly 370 (of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 330) with
 15 respect to the primary slat 110 and the secondary slat 120 in a manner such that the attachment arrangement 362 of the secondary-slat-support-frame 360 may engage with the retaining arrangement 128 of the elongated secondary-slat-body 122 and the attachment arrangement 352 of the primary-slat-support-frame 350 may engage with the retaining arrangement 118 of the elongated primary-slat-body 112. According to various
 20 embodiments, two or more intermediate assembly 370 may couple the primary slat 110 to the secondary slat 120 as shown in FIG. 3D and FIG. 3E.

[00079] According to various embodiments, the shutter curtain 301 may, similar to the shutter curtain 101 of FIG. 1A and FIG. 1B, further include the insulating material 140 inserted between each of the at least two primary slats 110 and the corresponding one of the
 25 at least two secondary slats 120. According to various embodiments, the insulating material 140 may be disposed to fill up remaining spaces, unoccupied by a corresponding one of the at least two thermal insulating units 330, between said primary slat 110 and said secondary slat 120. The remaining spaces may include a space between the elongated primary-slat-body 112 and the primary-slat-support-frame 350, a space between the elongated secondary-slat-body 122 and the secondary-slat-support-frame 360, as well as a space between the
 30 primary-slat-support-frame 350 and the secondary-slat-support frame 360. According to various embodiments, the insulating material 140 may be non-rigid insulating material.

According to various embodiments, the non-rigid insulating material may include, but not limited to, mineral wool, fiberglass, cellulose, polystyrene, polyurethane foam, etc.

[00080] According to various embodiments, the first longitudinal edge portion 125 and the second longitudinal edge portion 127 of the elongated secondary-slat-body 122 of each of the at least two secondary slats may serve as auxiliary retaining arrangement 142 for keeping the insulating material 140 in place, for example between the primary-slat-support-frame 350 and the secondary-slat-support frame 360. Accordingly, the auxiliary retaining arrangement 142 may act as a barrier to prevent the insulating material 140 from easily falling out after being inserted. According to various embodiments, the insulating material 140 may be inserted in a manner so as to abut against or contact the auxiliary retaining arrangement 142 such that the auxiliary retaining arrangement 142 may obstruct or block the insulating material 140 from falling out.

[00081] FIG. 4 shows a roller shutter 300 with the shutter curtain 301 according to various embodiments. According to various embodiments, the roller shutter 300 may, similar to the roller shutter 100 of FIG. 2, include the drum 105 and the shutter curtain 301 may be rolled on and rolled off the drum 105. According to various embodiments, similar to the roller shutter 100 of FIG. 2, a terminal end of the shutter curtain 301 may be attached to the drum 105 such that rotating the drum 105 may roll the shutter curtain 301 on the drum 105 or roll the shutter curtain 301 off the drum 105. Further, the shutter curtain 301 may be attached to the drum 105 in a manner such that the at least two primary slats 110 and the at least two secondary slats 120 may be parallel to a rotational axis of the drum 105. According to various embodiments, the shutter curtain 301 may be oriented such that the at least two primary slats 110 of the shutter curtain 301 may be directed towards the drum 105 and the at least two secondary slats 120 of the shutter curtain 301 may be directed away from the drum 105 when the shutter curtain 301 is wound round the drum 105. According to various embodiments, the drum 105 of the roller shutter 300 may be installed or mounted to the door head 106. Further, the roller shutter 300 may include the guide rails 108 installed or mounted to side casings or side walls. The guide rails 108 may serve to guide the shutter curtain 301 during rolling out (i.e. deployment) or rolling in (i.e. retraction).

[00082] FIG. 5A shows a shutter curtain 501 according to various embodiments, and FIG. 5B shows two links of the shutter curtain 501 of FIG. 5A pivoted with respect to each other according to various embodiments. FIG. 5C shows a disassembled view of a link of the shutter curtain 501 of FIG. 5A according to various embodiments. FIG. 5D shows an

assembled view of a link of the shutter curtain 501 of FIG. 5A according to various embodiments. FIG. 5E shows a front view of the link of FIG. 5D according to various embodiments.

[00083] According to various embodiments, the shutter curtain 501 may contain any one
5 or more or a combination of or all the parts and/or features and/or limitations of the shutter curtain 301 as described with reference to FIG. 3A and FIG. 3B. In the following, the shutter curtain 501 is described with like reference characters generally referring to the same or corresponding parts/features/limitations of the shutter curtain 301 of FIG. 3A and FIG. 3B. The description of the parts/features/limitations made with respect to the shutter curtain 301
10 of FIG. 3A and FIG. 3B are also applicable with respect to corresponding parts/features/limitations of the shutter curtain 501, and vice versa.

[00084] According to various embodiments, for example as shown in FIG. 5A and FIG. 5B, the shutter curtain 501 may include the at least two primary slats 110 with the primary-slat-support-frames 350, and the at least two secondary slats 120 with the secondary-slat-support-frames 360, which may be the same or identical with that of the shutter curtain 301
15 of FIG. 3A and FIG. 3B. Accordingly, all descriptions, changes, modifications, and variations that are applicable to the at least two primary slats 110 with the primary-slat-support-frames 350 of the shutter curtain 301 of FIG. 3A and FIG. 3B and/or the at least two secondary slats 120 with the secondary-slat-support-frames 360 of the shutter curtain
20 301 of FIG. 3A and FIG. 3B are also applicable to the at least two primary slats 110 with the primary-slat-support-frames 350 of the shutter curtain 501 and the at least two secondary slats 120 with the secondary-slat-support-frames 360 of the shutter curtain 501.

[00085] According to various embodiments, the shutter curtain 501 may, similar to the shutter curtain 301 of FIG. 3A and FIG. 3B, include at least two thermal insulating units
25 530. The at least two thermal insulating units 530 of the shutter curtain 501 may, similar to the at least two thermal insulating units 330 of the shutter curtain 301 of FIG. 3A and FIG. 3B, be connected between the at least two primary slats 110 and the at least two secondary slats 120 of the shutter curtain 501 to hold apart each of the at least two primary slats 110 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 501 in
30 a manner so as to thermally insulate (e.g. thermally separate) said primary slat 110 from said secondary slat 120. Accordingly, the at least two thermal insulating unit 530 of the shutter curtain 501 may thermally insulate (e.g. thermally separate) each of the at least two primary slats 110 of the shutter curtain 501 from the corresponding one of the at least two secondary

slats 120 of the shutter curtain 501. In other words, each of the at least two thermal insulating units 530 of the shutter curtain 501 may be connected between one of the at least two primary slats 110 of the shutter curtain 501 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 501 to hold apart said primary slat 110 and said secondary slat 120 in a manner so as to thermally insulate (e.g. thermally separate) said primary slat 110 from said secondary slat 120. For example, the first primary slat 110a of the at least two primary slats 110 of the shutter curtain 501 and a first secondary slat 120a of the at least two secondary slats 120 of the shutter curtain 501 may be held apart by a first thermal insulating unit 530a of the at least to two thermal insulating units 530 of the shutter curtain 501 to thermally insulate (e.g. thermally separate) the first primary slat 110a of the shutter curtain 501 and the first secondary slat 120a of the shutter curtain 501. Similarly, the second primary slat 110b of the at least two primary slats 110 of the shutter curtain 501 and a second secondary slat 120b of the at least two secondary slats 120 of the shutter curtain 501 may be held apart by a second thermal insulating unit 530b of the at least to two thermal insulating units 530 of the shutter curtain 501 to thermally insulate (e.g. thermally separate) the second primary slat 110b of the shutter curtain 501 and the second secondary slat 120b of the shutter curtain 501.

[00086] According to various embodiments, similar to the shutter curtain 301 of FIG. 3A and FIG. 3B, each of the at least two primary slats 110 of the shutter curtain 501 may be coupled to one portion (e.g. a first portion 534) of a corresponding thermal insulating unit 530 of the shutter curtain 501, and a corresponding one of the at least two secondary slats 120 of the shutter curtain 501 may be coupled to another portion (e.g. a second portion 536) of the corresponding thermal insulating unit 530 of the shutter curtain 501. According to various embodiments, said thermal insulating unit 530 may thermally separate said primary slat 110 of the shutter curtain 501 and said corresponding secondary slat 120 of the shutter curtain 501 in a manner such that said primary slat 110 of the shutter curtain 501 may not be in any direct contact with said corresponding secondary slat 120 of the shutter curtain 501. Further, said thermal insulating unit 530 of the shutter curtain 501 may be connected between said primary slat 110 of the shutter curtain 501 and said second slat 120 of the shutter curtain 501 without any other thermal conductive component connected therebetween. Thus, said primary slat 110 of the shutter curtain 501 and said second slat 120 of the shutter curtain 501 may be free of any direct heat conduction path or “thermal bridge” therebetween. Therefore, said thermal insulating unit 530 of the shutter curtain 501 may

serve to break or isolate or cut thermal conduction between said primary slat 110 of the shutter curtain 501 and said secondary slat 120 of the shutter curtain 501. Hence, the thermal insulation integrity between said primary slat 110 of the shutter curtain 501 and said secondary slat 120 of the shutter curtain 501 may be preserved and said thermal insulating unit 530 of the shutter curtain 501 may effectively thermally insulate (e.g. thermally separate) said primary slat 110 of the shutter curtain 501 from said secondary slat 120 of the shutter curtain 501, and vice versa.

[00087] Similar to the shutter curtain 301 of FIG. 3A and FIG. 3B, with the at least two thermal insulating unit 530 of the shutter curtain 501 thermally insulating (e.g. thermally separating) the at least two secondary slats 120 of the shutter curtain 501 and the at least two primary slats 110 of the shutter curtain 501, a first side 501a (formed by the at least two primary slats) and a second side 501b (formed by the at least two secondary slats) of the shutter curtain 501 may be thermally insulated (e.g. thermally separated) from each other via the at least two thermal insulating unit 530 of the shutter curtain 501. According to various embodiments, the shutter curtain 501 may provide a simple and sleek configuration with thermal insulation capability, whereby the at least two primary slats 110 of the shutter curtain 501 may form the continuous and seamless first side 501a of the shutter curtain 501, the at least two secondary slats 120 of the shutter curtain 501 may form the second side 501b of the shutter curtain 501, and the at least two thermal insulating unit 530 of the shutter curtain 501 may thermally insulate (e.g. thermally separate) the first side 501a and the second side 501b of the shutter curtain 501, without requiring additional components to join the slats together or to insulate the first side and the second side.

[00088] According to various embodiments, each of the at least two thermal insulating unit 530 of the shutter curtain 501 may include a thermal-insulating assembly 580 instead of the rigid thermal-insulating-body 332 of the thermal-insulating unit 330 of the shutter curtain 301 of FIG. 3A and FIG. 3B. According to various embodiments, the thermal-insulating assembly 580 may include a first thermal-insulating arrangement 582 (serving as the first portion 534), a second thermal-insulating arrangement 584 (serving as the second portion 536), and a bridging member 586, wherein the first thermal-insulating arrangement 582 is attached to a first segment 586a of the bridging member 586 and the second thermal-insulating arrangement 584 is attached to a second segment 586b of the bridging member 586. According to various embodiments (for example as shown in FIG. 5F), the first thermal-insulating arrangement 582 may include a first pair of thermal-insulating members

583a, 583b clamping the first segment 586a of the bridging member 586, and the second thermal-insulating arrangement 584 may include a second pair of thermal-insulating members 585a, 585b clamping the second segment 586b of the bridging member 586. The first segment 586a and the second segment 586b may be opposite end portions of the bridging member 586. According to various embodiments, the first pair of thermal-insulating members 583a, 583b may include a main thermal-insulating member 583a and an auxiliary thermal-insulating member 583b, and the second pair of thermal-insulating members 585a, 585b may include a main thermal-insulating member 585a and an auxiliary thermal-insulating member 585b. The main thermal-insulating member 583a of the first pair of thermal-insulating members 583a, 583b and the main thermal-insulating member 585a of the second pair of thermal-insulating members 585a, 585b may be on opposite sides of the bridging member 586. Similarly, the auxiliary thermal-insulating member 583b of the first pair of thermal-insulating members 583a, 583b and the auxiliary thermal-insulating member 585b of the second pair of thermal-insulating members 585a, 585b may be on opposite sides of the bridging member 586.

[00089] According to various embodiments, each insulating members 583a, 583b, 585a, 585b of the first pair of thermal-insulating members 583a, 583b and the second pair of thermal-insulating members 585a, 585b may be stiff or unyielding or non-pliant or non-flexible such that the thermal-insulating assembly 580 may firmly hold a corresponding one of the at least two primary slats 110 of the shutter curtain 501 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 501 in a fixed disposition relative to each other. Accordingly, the thermal-insulating assembly 580 may have a rigidity or stiffness to fixedly hold said primary slat 110 of the shutter curtain 501 and said secondary slat 120 of the shutter curtain 501 in a manner such that said primary slat 110 of the shutter curtain 501 and said secondary slat 120 of the shutter curtain 501 may be immovable relative to each other. Hence said primary slat 110 of the shutter curtain 501 and said secondary slat 120 of the shutter curtain 501 may be held in place in the fixed disposition relative to each other by the thermal-insulating assembly 580.

[00090] According to various embodiments, each insulating members 583a, 583b, 585a, 585b of the first pair of thermal-insulating members 583a, 583b and the second pair of thermal-insulating members 585a, 585b may include a slab or panel or block of rigid solid thermal-insulating material including, but not limited to, wood, ceramic, plastic, glass, or carbon. According to various embodiments, each insulating members 583a, 583b, 585a,

- 585b of the first pair of thermal-insulating members 583a, 583b and the second pair of thermal-insulating members 585a, 585b may include, but not limited to a rigid solid structure/shape, a rigid lattice structure/shape, or a rigid frame structure/shape. According to various embodiments, each insulating members 583a, 583b, 585a, 585b of the first pair
- 5 of thermal-insulating members 583a, 583b and the second pair of thermal-insulating members 585a, 585b may include, but not limited to, a rigid composite assembly such as a sandwich-structured composite, or a rigid composite material such as fibre-reinforced plastic or glass-reinforced plastic. According to various embodiments, when each insulating members 583a, 583b, 585a, 585b of the first pair of thermal-insulating members 583a, 583b
- 10 and the second pair of thermal-insulating members 585a, 585b is a rigid composite assembly or a rigid composite material, each insulating members 583a, 583b, 585a, 585b may include one or a combination of thermal-insulating material including, but not limited to, wood, ceramic, plastic, glass, carbon, mineral wool, fiberglass, cellulose, polystyrene, polyurethane foam, etc.
- 15 **[00091]** According to various embodiments, the bridging member 586 may include a bracket, a panel, a plate, a frame, or any suitable rigid structure to hold the first pair of thermal-insulating members 583a, 583b and the second pair of thermal-insulating members 585a, 585b together as an assembly. According to various embodiments, the bridging member 586 may be made of any rigid materials including, but not limited to, metallic
- 20 materials (such as aluminium, steel, stainless steel, etc.), composite materials, plastics, wood, etc.. According to an implementation, each insulating members 583a, 583b, 585a, 585b of the first pair of thermal-insulating members 583a, 583b and the second pair of thermal-insulating members 585a, 585b may be made of ceramic and the bridging member 586 may be made of steel.
- 25 **[00092]** According to various embodiments, the recess portion 368 of the secondary-slat-support-frame 360 may hold the first thermal-insulating arrangement 582 (serving as the first portion 534) of the thermal-insulating assembly 580 to the secondary-slat-support-frame 360 for coupling the thermal-insulating assembly 580 to the elongated secondary-slat-body 122. According to various embodiments, the recess portion 368 of the secondary-
- 30 slat-support-frame 360 may hold, or support, or secure the first thermal-insulating arrangement 582 (serving as the first portion 534) of the thermal-insulating assembly 580 to the secondary-slat-support-frame 360 so as to keep the thermal-insulating assembly 580 from falling in order to maintain it in position with respect to the secondary-slat-support-

frame 360 and/or the elongated secondary-slat-body 122. Hence, the recess portion 368 of the secondary-slat-support-frame 360 may hold or support, or secure the first thermal-insulating arrangement 582 (serving as the first portion 534) of the thermal-insulating assembly 580 in a fixed disposition relative to each other. According to various
5 embodiments, the recess portion 368 of the secondary-slat-support-frame 360 may be in direct engagement with the first thermal-insulating arrangement 582 (serving as the first portion 534) of the thermal-insulating assembly 580 as shown in FIG. 5A to FIG. 5B. Accordingly, the first thermal-insulating arrangement 582 (serving as the first portion 534) of the thermal-insulating assembly 580 may be in direct contact or abutment with the recess
10 portion 368 of the secondary-slat-support-frame 360.

[00093] According to various embodiments, the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 may be inserted into the recess portion 368 of the secondary-slat-support-frame 360 and be retained in the recess portion 368 of the secondary-slat-support-frame 360. According to various
15 embodiments, the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 of each of the at least two thermal insulating units 530 of the shutter curtain 501 may include an engagement arrangement 535 for coupling the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 to the recess portion 368 of the secondary-slat-support-frame 360. According to various
20 embodiments, the engagement arrangement 535 of the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 may include a profile complementary to the recess portion 368 of the secondary-slat-support-frame 360 to facilitate engagement and coupling. Hence, depending on the configuration of the recess portion 368 of the secondary-slat-support-frame 360, the
25 engagement arrangement 535 of the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 may be configured accordingly. According to various embodiments, the recess portion 368 of the secondary-slat-support-frame 360 may hold the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 via
30 interference fit or friction or fastening means. The fastening means may include, but not limited to, adhesive, snap-fit, snap-fastener, rivet, bolt and nut, screw, pin, nail, latch, catch, or clamp. Accordingly, the engagement arrangement 535 of the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating

assembly 580 may be configured accordingly to have a complementing shape, dimensions, texture, and/or fastening elements.

[00094] Referring to FIG. 5F, according to various embodiments, a bolt 588a may be inserted through a hole in the recess portion 368 of the secondary-slat-support-frame 360, through a hole in the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580, through a hole in the first segment 586a of the bridging member 586 and through a hole in the auxiliary thermal-insulating member 583b of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 in a manner such that a nut 588b tightened onto the bolt 588a from an end of the bolt 588a protruding from the auxiliary thermal-insulating member 583b of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 may fasten the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 to the recess portion 358 of the primary-slat-support-frame 350 while the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 and the auxiliary thermal-insulating member 583b of the first thermal-insulating arrangement 582 clamp the first segment 586a of the bridging member 586. The hole of the first segment 586a of the bridging member 586 may be larger than a diameter of the bolt 588a such that the bolt 588a may not be in contact with the first segment 586a of the bridging member 586 when the nut 588b is tightened to clamp the first segment 586a of the bridging member 586 between the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 and the auxiliary thermal-insulating member 583b of the first thermal-insulating arrangement 582.

[00095] According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may hold the second thermal-insulating arrangement 584 (serving as the second portion 536) of the thermal-insulating assembly 580 to the primary-slat-support-frame 350 for coupling the thermal-insulating assembly 580 to the elongated primary-slat-body 112. According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may hold, or support, or secure the second thermal-insulating arrangement 584 (serving as the second portion 536) of the thermal-insulating assembly 580 to the primary-slat-support-frame 350 so as to keep the thermal-insulating assembly 580 from falling in order to maintain it in position with respect to the primary-slat-support-frame 350 and/or the elongated primary-slat-body 112. Hence, the recess portion 358 of the primary-slat-support-frame 350 may hold or support, or secure the second thermal-insulating arrangement 584 (serving as the second portion 536) of the thermal-insulating

assembly 580 in a fixed disposition relative to each other. According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may be in direct engagement with the second thermal-insulating arrangement 584 (serving as the second portion 536) of the thermal-insulating assembly 580 as shown in FIG. 5A to FIG. 5B.

5 Accordingly, the second thermal-insulating arrangement 584 (serving as the second portion 536) of the thermal-insulating assembly 580 may be in direct contact or abutment with the recess portion 358 of the primary-slat-support-frame 350.

[00096] According to various embodiments, the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 may be inserted into the recess portion 358 of the primary-slat-support-frame 350 and be retained in the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 of each of the at least two thermal insulating units 530 of the shutter curtain 501 may include an engagement arrangement 537 for coupling the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 to the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the engagement arrangement 537 of the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 may include a profile complementary to the recess portion 358 of the primary-slat-support-frame 350 to facilitate engagement and coupling. Hence, depending on the configuration of the recess portion 358 of the primary-slat-support-frame 350, the engagement arrangement 537 of the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 may be configured accordingly. According to various embodiments, the recess portion 358 of the primary-slat-support-frame 350 may hold the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 via interference fit or friction or fastening means. The fastening means may include, but not limited to, adhesive, snap-fit, snap-fastener, rivet, bolt and nut, screw, pin, nail, latch, catch, or clamp. Accordingly, the engagement arrangement 537 of the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 may be configured accordingly to have a complementing shape, dimensions, texture, and/or fastening elements.

[00097] Referring to FIG. 5A, according to various embodiments, a bolt 589a may be inserted through a hole in the recess portion 358 of the primary-slat-support-frame 350, through a hole in the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580, through a hole in the second segment 586b of the bridging member 582 and through a hole in the auxiliary thermal-insulating member 585b of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 in a manner such that a nut 589b tightened onto the bolt 589a from an end of the bolt 589a protruding from the auxiliary thermal-insulating member 585b of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 may fasten the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 to the recess portion 358 of the primary-slat-support-frame 350 while the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 and the auxiliary thermal-insulating member 585b of the second thermal-insulating arrangement 584 clamp the second segment 586b of the bridging member 586. The hole of the second segment 586b of the bridging member 586 may be larger than a diameter of the bolt 589a such that the bolt 589a may not be in contact with the second segment 586b of the bridging member 586 when the nut 589b is tightened to clamp the second segment 586b of the bridging member 586 between the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 and the auxiliary thermal-insulating member 585b of the second thermal-insulating arrangement 584.

[00098] FIG. 5F shows a disassembled view of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 530 according to various embodiments. FIG. 5G shows an assembled view of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 530 according to various embodiments. According to various embodiments, the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 530 may be assembled together to form an intermediate assembly 570 in a manner whereby the engagement arrangement 535 of the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 may be coupled to the recess portion 368 of the secondary-slat-support-frame 360 and the engagement arrangement 537 of the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 may be coupled to the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the engagement

arrangement 535 of the main thermal-insulating member 583a of the first thermal-insulating arrangement 582 of the thermal-insulating assembly 580 may be fitted into the recess portion 368 of the secondary-slat-support-frame 360 and fastened together, for example via the bolt 588a and nut 588b. According to various embodiments, the engagement arrangement 537 of the main thermal-insulating member 585a of the second thermal-insulating arrangement 584 of the thermal-insulating assembly 580 may be fitted to the recess portion 358 of the primary-slat-support-frame 350 and fastened together, for example via the bolt 589a and nut 589b.

[00099] Referring to FIG. 5C and FIG. 5D, according to various embodiments, the primary slat 110, the secondary slat 120 and the thermal insulating unit 530 may be assembled together by sliding the intermediate assembly 570 (of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 530) with respect to the primary slat 110 and the secondary slat 120 in a manner such that the attachment arrangement 362 of the secondary-slat-support-frame 360 may engage with the retaining arrangement 128 of the elongated secondary-slat-body 122 and the attachment arrangement 352 of the primary-slat-support-frame 350 may engage with the retaining arrangement 118 of the elongated primary-slat-body 112. According to various embodiments, two or more intermediate assembly 570 may couple the primary slat 110 to the secondary slat 120 as shown in FIG. 5D and FIG. 5E.

[000100] FIG. 6 shows a roller shutter 500 with the shutter curtain 501 according to various embodiments. According to various embodiments, the roller shutter 500 may, similar to the roller shutter 100 of FIG. 2 and roller shutter 300 of FIG. 4, include the drum 105 and the shutter curtain 501 may be rolled on and rolled off the drum 105. According to various embodiments, similar to the roller shutter 100 of FIG. 2 and roller shutter 300 of FIG. 4, a terminal end of the shutter curtain 501 may be attached to the drum 105 such that rotating the drum 105 may roll the shutter curtain 501 on the drum 105 or roll the shutter curtain 501 off the drum 105. Further, the shutter curtain 501 may be attached to the drum 105 in a manner such that the at least two primary slats 110 and the at least two secondary slats 120 may be parallel to a rotational axis of the drum 105. According to various embodiments, the shutter curtain 501 may be oriented such that the at least two primary slats 110 of the shutter curtain 501 may be directed towards the drum 105 and the at least two secondary slats 120 of the shutter curtain 501 may be directed away from the drum 105 when the shutter curtain 501 is wound round the drum 105. According to various

embodiments, the drum 105 of the roller shutter 500 may be installed or mounted to the door head 106. Further, the roller shutter 500 may include the guide rails 108 installed or mounted to side casings or side walls. The guide rails 108 may serve to guide the shutter curtain 501 during rolling out (i.e. deployment) or rolling in (i.e. retraction).

5 **[000101]** FIG. 7A shows a shutter curtain 701 according to various embodiments, and FIG. 7B shows two links of the shutter curtain 701 of FIG. 7A pivoted with respect to each other according to various embodiments. FIG. 7C shows a disassembled view of a link of the shutter curtain 701 of FIG. 7A according to various embodiments. FIG. 7D shows an assembled view of a link of the shutter curtain 701 of FIG. 7A according to various
10 embodiments. FIG. 7E shows a front view of the link of FIG. 7D according to various embodiments.

[000102] According to various embodiments, the shutter curtain 701 may contain any one or more or a combination of or all the parts and/or features and/or limitations of the shutter curtain 501 as described with reference to FIG. 5A and FIG. 5B. In the following, the shutter
15 curtain 701 is described with like reference characters generally referring to the same or corresponding parts/features/limitations of the shutter curtain 501 of FIG. 5A and FIG. 5B. The description of the parts/features/limitations made with respect to the shutter curtain 501 of FIG. 5A and FIG. 5B are also applicable with respect to corresponding parts/features/limitations of the shutter curtain 701, and vice versa.

20 **[000103]** According to various embodiments, for example as shown in FIG. 7A and FIG. 7B, the shutter curtain 701 may include the at least two primary slats 110 with the primary-slat-support-frames 350, and the at least two secondary slats 120 with the secondary-slat-support-frames 360, which may be the same or identical with that of the shutter curtain 501 of FIG. 5A and FIG. 5B. Accordingly, all descriptions, changes, modifications, and
25 variations that are applicable to the at least two primary slats 110 with the primary-slat-support-frames 350 of the shutter curtain 501 of FIG. 5A and FIG. 5B and/or the at least two secondary slats 120 with the secondary-slat-support-frames 360 of the shutter curtain 501 of FIG. 5A and FIG. 5B are also applicable to the at least two primary slats 110 with the primary-slat-support-frames 350 of the shutter curtain 701 and the at least two secondary
30 slats 120 with the secondary-slat-support-frames 360 of the shutter curtain 701.

[000104] According to various embodiments, the shutter curtain 701 may, similar to the shutter curtain 501 of FIG. 5A and FIG. 5B, include at least two thermal insulating units 730. The at least two thermal insulating units 730 of the shutter curtain 701 may, similar to

the at least two thermal insulating units 530 of the shutter curtain 501 of FIG. 5A and FIG. 5B, be connected between the at least two primary slats 110 and the at least two secondary slats 120 of the shutter curtain 701 to hold apart each of the at least two primary slats 110 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 701 in a manner so as to thermally insulate said primary slat 110 from said secondary slat 120 (e.g. reduce thermal conduction therebetween). Accordingly, the at least two thermal insulating unit 730 of the shutter curtain 701 may thermally insulate each of the at least two primary slats 110 of the shutter curtain 701 from the corresponding one of the at least two secondary slats 120 of the shutter curtain 701 (e.g. reduce thermal conduction therebetween). In other words, each of the at least two thermal insulating units 730 of the shutter curtain 701 may be connected between one of the at least two primary slats 110 of the shutter curtain 701 and a corresponding one of the at least two secondary slats 120 of the shutter curtain 701 to hold apart said primary slat 110 and said secondary slat 120 in a manner so as to thermally insulate said primary slat 110 from said secondary slat 120 (e.g. reduce thermal conduction therebetween). For example, the first primary slat 110a of the at least two primary slats 110 of the shutter curtain 701 and a first secondary slat 120a of the at least two secondary slats 120 of the shutter curtain 701 may be held apart by a first thermal insulating unit 730a of the at least to two thermal insulating units 730 of the shutter curtain 701 to thermally insulate the first primary slat 110a of the shutter curtain 701 and the first secondary slat 120a of the shutter curtain 701 (e.g. reduce thermal conduction therebetween). Similarly, the second primary slat 110b of the at least two primary slats 110 of the shutter curtain 701 and a second secondary slat 120b of the at least two secondary slats 120 of the shutter curtain 701 may be held apart by a second thermal insulating unit 730b of the at least to two thermal insulating units 730 of the shutter curtain 701 to thermally insulate the second primary slat 110b of the shutter curtain 701 and the second secondary slat 120b of the shutter curtain 701 (e.g. reduce thermal conduction therebetween).

[000105] According to various embodiments, similar to the shutter curtain 501 of FIG. 5A and FIG. 5B, each of the at least two primary slats 110 of the shutter curtain 701 may be coupled to one portion (e.g. a first portion 734) of a corresponding thermal insulating unit 730 of the shutter curtain 701, and a corresponding one of the at least two secondary slats 120 of the shutter curtain 701 may be coupled to another portion (e.g. a second portion 736) of the corresponding thermal insulating unit 730 of the shutter curtain 701. According to various embodiments, said thermal insulating unit 730 may thermally separate said primary

slat 110 of the shutter curtain 701 and said corresponding secondary slat 120 of the shutter curtain 701 in a manner such that said primary slat 110 of the shutter curtain 701 may only have negligible or insignificant or minimal thermal transfer with said corresponding secondary slat 120 of the shutter curtain 701. Further, said thermal insulating unit 730 of the shutter curtain 701 may serve as a thermal break or thermal barrier to reduce thermal conductivity between said primary slat 110 of the shutter curtain 701 and said second slat 120 of the shutter curtain 701. Thus, said primary slat 110 of the shutter curtain 701 and said second slat 120 of the shutter curtain 701 may have low thermal conductivity therebetween. Therefore, said thermal insulating unit 730 of the shutter curtain 701 may serve to reduce or resist or obstruct thermal conduction between said primary slat 110 of the shutter curtain 701 and said secondary slat 120 of the shutter curtain 701. Hence, the thermal insulation integrity between said primary slat 110 of the shutter curtain 701 and said secondary slat 120 of the shutter curtain 701 may be preserved and said thermal insulating unit 730 of the shutter curtain 701 may effectively thermally insulate said primary slat 110 of the shutter curtain 701 from said secondary slat 120 of the shutter curtain 701 (e.g. reduce thermal conduction therebetween), and vice versa.

[000106] Similar to the shutter curtain 501 of FIG. 5A and FIG. 5B, with the at least two thermal insulating unit 730 of the shutter curtain 701 thermally insulating the at least two secondary slats 120 of the shutter curtain 701 and the at least two primary slats 110 of the shutter curtain 701 (e.g. reduce thermal conduction therebetween), a first side 701a (formed by the at least two primary slats) and a second side 701b (formed by the at least two secondary slats) of the shutter curtain 701 may be thermally insulated from each other (e.g. reduce thermal conduction therebetween) via the at least two thermal insulating unit 730 of the shutter curtain 701. According to various embodiments, the shutter curtain 701 may provide a simple and sleek configuration with thermal insulation capability, whereby the at least two primary slats 110 of the shutter curtain 701 may form the continuous and seamless first side 701a of the shutter curtain 701, the at least two secondary slats 120 of the shutter curtain 701 may form the second side 701b of the shutter curtain 701, and the at least two thermal insulating unit 730 of the shutter curtain 701 may thermally insulate (e.g. thermally separate) the first side 701a and the second side 701b of the shutter curtain 701, without requiring additional components to join the slats together or to insulate the first side and the second side.

[000107] According to various embodiments, each of the at least two thermal insulating unit 730 of the shutter curtain 701 may, similar to the shutter curtain 501 of FIG. 5A and FIG. 5B, include a thermal-insulating assembly 780. According to various embodiments, the thermal-insulating assembly 780 may include a first thermal-insulating arrangement 782 (serving as the first portion 734), a second thermal-insulating arrangement 784 (serving as the second portion 736), and a bridging member 586, wherein the first thermal-insulating arrangement 782 is attached to a first segment 586a of the bridging member 586 and the second thermal-insulating arrangement 784 is attached to a second segment 586b of the bridging member 586. According to various embodiments (for example as shown in FIG. 7F), the first thermal-insulating arrangement 782 may include a thermal-insulating member 583a attached to the first segment 586a of the bridging member 586, and the second thermal-insulating arrangement 784 may include a thermal-insulating member 585a attached to the second segment 586b of the bridging member 586.

[000108] According to various embodiments, each thermal-insulating member 583a, 585a of the first thermal-insulating arrangement 782 and the second thermal-insulating arrangement 784 of the thermal-insulating assembly 780 may respectively be the same or identical with the main thermal-insulating member 583a of the first pair of thermal-insulating members 583a, 583b and the main thermal-insulating member 585a of the second pair of thermal-insulating members 585a, 585b of the thermal-insulating assembly 580 of the shutter curtain 501 of FIG. 5A and FIG. 5B. According to various embodiments, the bridging member 586 of the thermal-insulating assembly 780 may be the same or identical with the bridging member 586 of the thermal-insulating assembly 580 of the shutter curtain 501 of FIG. 5A and FIG. 5B. Accordingly, all relevant descriptions, changes, modifications, and variations with respect to the thermal-insulating assembly 580 of the shutter curtain 501 of FIG. 5A and FIG. 5B are also applicable to the thermal-insulating assembly 780 of the shutter curtain 701.

[000109] According to various embodiments, the thermal-insulating assembly 780 of the shutter curtain 701 differs from the thermal-insulating assembly 580 of the shutter curtain 501 of FIG. 5A and FIG. 5B in that first thermal-insulating arrangement 782 is without the auxiliary thermal-insulating member 583b and the second thermal-insulating arrangement 784 is without the auxiliary thermal-insulating member 585b. Referring to FIG. 7F, according to various embodiments, a screw 788 may be inserted through a hole in the recess portion 368 of the secondary-slat-support-frame 360, through a hole in the thermal-

insulating member 583a of the first thermal-insulating arrangement 782 of the thermal-insulating assembly 780, and engage with a hole in the first segment 586a of the bridging member 586 in a manner such that the screw 788 may be tightened to (e.g. screwed into) the first segment 586a of the bridging member 586. In this manner, the first thermal-insulating arrangement 782 of the thermal-insulating assembly 780 may be coupled to the recess portion 358 of the primary-slat-support-frame 350 and with the thermal-insulating member 583a of the first thermal-insulating arrangement 782 secured to the first segment 586a of the bridging member 586 simultaneously. Further, according to various embodiments, a screw 789 may be inserted through a hole in the recess portion 358 of the primary-slat-support-frame 350, through a hole in the thermal-insulating member 585a of the second thermal-insulating arrangement 784 of the thermal-insulating assembly 780, and engage with a hole in the second segment 586b of the bridging member 586 in a manner such that the screw 789 may be tightened to (e.g. screwed into) the second segment 586b of the bridging member 586. In this manner, the second thermal-insulating arrangement 784 of the thermal-insulating assembly 780 may be coupled to the recess portion 358 of the primary-slat-support-frame 350 and with the main thermal-insulating member 585a of the second thermal-insulating arrangement 784 of the thermal-insulating assembly 780 secured to the second segment 586b of the bridging member 586 simultaneously. According to various embodiments, when the screws 788 and 789 are metallic screw, the screws 788 and 789 may conduct thermal energy from the primary-slat-support-frame 350 to the bridging member 586 and from the bridging member 586 to the secondary-slat-support-frame 360. However, the amount of thermal conduction may be minimal or negligible or insignificant. Accordingly, thermal-insulating unit 730 with the thermal-insulating assembly 780 may still thermally insulate the primary slat 110 from the secondary slat 120 by significantly reducing thermal conduction therebetween.

[000110] FIG. 7F shows a disassembled view of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 730 according to various embodiments. FIG. 7G shows an assembled view of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 730 according to various embodiments. According to various embodiments, the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 730 may be assembled together to form an intermediate assembly 770 in a manner whereby the thermal-insulating member 583a of the first thermal-insulating arrangement 782 of the thermal-insulating

assembly 780 may be coupled to the recess portion 368 of the secondary-slat-support-frame 360 and the thermal-insulating member 585a of the second thermal-insulating arrangement 784 of the thermal-insulating assembly 780 may be coupled to the recess portion 358 of the primary-slat-support-frame 350. According to various embodiments, the thermal-insulating member 583a of the first thermal-insulating arrangement 782 of the thermal-insulating assembly 780 may be fitted into the recess portion 368 of the secondary-slat-support-frame 360 and fastened together, for example via the screw 788. According to various embodiments, the thermal-insulating member 585a of the second thermal-insulating arrangement 784 of the thermal-insulating assembly 780 may be fitted to the recess portion 358 of the primary-slat-support-frame 350 and fastened together, for example via the screw 789.

[000111] Referring to FIG. 7C and FIG. 7D, according to various embodiments, the primary slat 110, the secondary slat 120 and the thermal insulating unit 730 may be assembled together by sliding the intermediate assembly 770 (of the primary-slat-support-frame 350, the secondary-slat-support-frame 360 and the thermal insulating unit 730) with respect to the primary slat 110 and the secondary slat 120 in a manner such that the attachment arrangement 362 of the secondary-slat-support-frame 360 may engage with the retaining arrangement 128 of the elongated secondary-slat-body 122 and the attachment arrangement 352 of the primary-slat-support-frame 350 may engage with the retaining arrangement 118 of the elongated primary-slat-body 112. According to various embodiments, two or more intermediate assembly 770 may couple the primary slat 110 to the secondary slat 120 as shown in FIG. 7D and FIG. 7E.

[000112] FIG. 8 shows a roller shutter 700 with the shutter curtain 701 according to various embodiments. According to various embodiments, the roller shutter 700 may, similar to the roller shutter 100 of FIG. 2 and roller shutter 300 of FIG. 4 and the roller shutter 500 of FIG. 6, include the drum 105 and the shutter curtain 701 may be rolled on and rolled off the drum 105. According to various embodiments, similar to the roller shutter 100 of FIG. 2 and roller shutter 300 of FIG. 4 and the roller shutter of FIG. 6, a terminal end of the shutter curtain 701 may be attached to the drum 105 such that rotating the drum 105 may roll the shutter curtain 701 on the drum 105 or roll the shutter curtain 701 off the drum 105. Further, the shutter curtain 701 may be attached to the drum 105 in a manner such that the at least two primary slats 110 and the at least two secondary slats 120 may be parallel to a rotational axis of the drum 105. According to various embodiments, the shutter curtain

701 may be oriented such that the at least two primary slats 110 of the shutter curtain 701 may be directed towards the drum 105 and the at least two secondary slats 120 of the shutter curtain 701 may be directed away from the drum 105 when the shutter curtain 701 is wound round the drum 105. According to various embodiments, the drum 105 of the roller shutter 700 may be installed or mounted to the door head 106. Further, the roller shutter 700 may include the guide rails 108 installed or mounted to side casings or side walls. The guide rails 108 may serve to guide the shutter curtain 701 during rolling out (i.e. deployment) or rolling in (i.e. retraction).

[000113] The following examples pertain to various embodiments.

10 **[000114]** Example 1 is a shutter curtain including:

at least two primary slats pivotally interlocked in a longitudinal-edge-to-longitudinal-edge arrangement one after another, wherein each of the at least two primary slats includes an elongated primary-slat-body having a longitudinal axis, the elongated primary-slat-body being integrally formed with a first interlockable longitudinal edge portion and a second interlockable longitudinal edge portion, the first interlockable longitudinal edge portion and the second interlockable longitudinal edge portion of the elongated primary-slat-body being opposite each other on opposite sides of the longitudinal axis of the elongated primary-slat-body, wherein the first interlockable longitudinal edge portion of the elongated primary-slat-body of a first primary slat of the at least two primary slats is pivotally interlocked with the second interlockable longitudinal edge portion of the elongated primary-slat-body of a second primary slat of the at least two primary slats to form a pivotable joint between the at least two primary slats, wherein a pivot axis of the pivotable joint is parallel to the longitudinal axis of the elongated primary-slat-body;

at least two secondary slats unconnected from each other; and

25 at least two thermal insulating units respectively connected between the at least two primary slats and the at least two secondary slats to hold apart each of the at least two primary slats and a corresponding one of the at least two secondary slats in a manner so as to thermally separate said primary slat from said secondary slat.

[000115] In Example 2, the subject matter of Example 1 may optionally include that each of the at least two secondary slats may include an elongated secondary-slat-body having a longitudinal axis, the elongated secondary-slat-body being integrally formed with a first engagement longitudinal portion and a second engagement longitudinal portion, the first engagement longitudinal portion and the second engagement longitudinal portion of the

elongated secondary-slat-body being opposite each other on opposite sides of the longitudinal axis of the elongated secondary-slat-body, wherein the elongated secondary-slat-body of a first secondary slat of the at least two secondary slats may be stackable on the elongated secondary-slat-body of a second secondary slat of the at least two secondary slats
 5 with the first engagement longitudinal portion of the elongated secondary-slat-body of the first secondary slat in engagement with the second engagement longitudinal portion of the elongated secondary-slat-body of the second secondary slat.

[000116] In Example 3, the subject matter of Example 2 may optionally include that the engagement between the first engagement longitudinal portion of the elongated secondary-slat-body of the first secondary slat and the second engagement longitudinal portion of the elongated secondary-slat-body of the second secondary slat may be a mesh-type engagement which forms a separable lap joint or a separable overlap joint or a separable tongue-and-groove joint.
 10

[000117] In Example 4, the subject matter of Example 2 or 3 may optionally include that a cross-section of the first engagement longitudinal portion of the elongated secondary-slat-body of each of the at least two secondary slats may include an insert profile and a cross-section of the second engagement longitudinal portion of the elongated secondary-slat-body of each of the at least two secondary slats comprises a complementary recess profile.
 15

[000118] In Example 5, the subject matter of any one of Examples 2 to 4 may optionally include that the elongated secondary-slat-body of each of the at least two secondary slats may further include a retaining arrangement to hold a first portion of a corresponding one of the at least two thermal insulating units to the elongated secondary-slat-body.
 20

[000119] In Example 6, the subject matter of Example 5 may optionally include that the retaining arrangement of the elongated secondary-slat-body may include a pair of opposing lip formations extending towards each other from opposite longitudinal edge portions of the elongated secondary-slat-body.
 25

[000120] In Example 7, the subject matter of Example 6 may optionally include that each of the pair of opposing lip formations of the retaining arrangement of the elongated secondary-slat-body may be formed by folding over a corresponding segment of the elongated secondary-slat-body.
 30

[000121] In Example 8, the subject matter of Example 6 or 7 may optionally include that the first portion of the corresponding one of the at least two thermal insulating units may include a pair of transverse protrusions extending in opposite directions, the pair of

transverse protrusions being respectively in engagement with the pair of opposing lip formations of the retaining arrangement of the elongated secondary-slat-body for connecting the first portion of the corresponding one of the at least two thermal insulating units to the elongated secondary-slat-body.

- 5 **[000122]** In Example 9, the subject matter of Example 6 or 7 may optionally include that each of the at least two secondary slats may further include a secondary-slat-support-frame coupled to the elongated secondary-slat-body, the secondary-slat-support-frame having a pair of grooves directed away from each other along two opposite edge portions of the secondary-slat-support-frame, and a recess portion between the two opposite edge portions
10 of the secondary-slat-support-frame,

wherein the secondary-slat-support-frame may be coupled to the elongated secondary-slat-body with the pair of grooves of the secondary-slat-support-frame respectively slide over the pair of opposing lip formations of the elongated secondary-slat-body,

- 15 wherein the first portion of the corresponding one of the at least two thermal insulating units may be inserted and retained in the recess portion of the secondary-slat-support-frame.

- [000123]** In Example 10, the subject matter of Example 9 may optionally include that the secondary-slat-support-frame may be made from a sheet of material roll-formed to bend the
20 two opposite edge portions of the secondary-slat-support-frame to form the pair of grooves and to bend a region between the two opposite edge portions of the secondary-slat-support-frame to form an open channel defining the recess portion.

- [000124]** In Example 11, the subject matter of any one of Examples 5 to 10 may optionally include that the elongated secondary-slat-body may be made from a sheet of material roll-
25 formed to integrally form the first engagement longitudinal portion, the second engagement longitudinal portion, and the retaining arrangement.

- [000125]** In Example 12, the subject matter of any one of Examples 1 to 10 may optionally include that the elongated primary-slat-body of each of the at least two primary slats may further include a retaining arrangement to hold a second portion of a corresponding one of
30 the at least two thermal insulating units to the elongated primary-slat-body.

[000126] In Example 13, the subject matter of Example 12 may optionally include that the retaining arrangement of the elongated primary-slat-body may include a pair of opposing lip formations extending towards each other respectively from the first interlockable

longitudinal edge portion and the second interlockable longitudinal edge portion of the elongated primary-slat-body.

[000127] In Example 14, the subject matter of Example 13 may optionally include that each of the pair of opposing lip formations of the retaining arrangement of the elongated primary-slat-body may be formed by folding over a corresponding segment of the elongated secondary-slat-body.

[000128] In Example 15, the subject matter of Example 13 or 14 may optionally include that the second portion of the corresponding one of the at least two thermal insulating units may include a pair of transverse protrusions extending in opposite directions, the pair of transverse protrusions being respectively in engagement with the pair of opposing lip formations of the retaining arrangement of the elongated primary-slat-body for connecting the second portion of the corresponding one of the at least two thermal insulating units to the elongated primary-slat-body.

[000129] In Example 16, the subject matter of Example 13 or 14 may optionally include that each of the at least two primary slats further may include a primary-slat-support-frame coupled to the elongated primary-slat-body, the primary-slat-support-frame having a pair of grooves directed away from each other along two opposite edge portions of the primary-slat-support-frame, and a recess portion between the two opposite edge portions of the primary-slat-support-frame,

wherein the primary-slat-support-frame may be coupled to the elongated primary-slat-body with the pair of grooves of the primary-slat-support-frame respectively slide over the pair of opposing lip formations of the elongated primary-slat-body,

wherein the second portion of the corresponding one of the at least two thermal insulating units may be inserted and retained in the recess portion of the primary-slat-support-frame.

[000130] In Example 17, the subject matter of Example 16 may optionally include that the primary-slat-support-frame may be made from a sheet of material roll-formed to bend the two opposite edge portions of the primary-slat-support-frame to form the pair of grooves and to bend a region between the two opposite edge portions of the primary-slat-support-frame to form an open channel defining the recess portion.

[000131] In Example 18, the subject matter of any one of Examples 12 to 17 may optionally include that the elongated primary-slat-body may be made from a sheet of

material roll-formed to integrally form the first interlockable longitudinal edge portion, the second interlockable longitudinal edge portion, and the retaining arrangement.

[000132] In Example 19, the subject matter of any one of Examples 1 to 18 may optionally include insulating material inserted between each of the at least two primary slats and the
5 corresponding one of the at least two secondary slats, wherein the elongated secondary-slat-body of each of the at least two secondary slats may further include an auxiliary retaining arrangement to keep the insulating material in place.

[000133] Example 20 is a roller shutter including:

a drum; and
10 the shutter curtain according to any one of Examples 1 to 19, wherein the shutter curtain may be attached to the drum in a manner so as to be capable of being rolled on and off the drum when the drum is being rotated.

[000134] Various embodiments have provided a shutter curtain which include a first set of slats and a second set of slats held together by thermal-insulating members such that there
15 is no thermal conductive component directly connecting the first set of slats to the second set of slats. Accordingly, the shutter curtain may be free of any “thermal bridge” between the first set of slats and the second set of slats. Further, the first set of slats and the second set of slats may be connected by the thermal-insulating members in a manner such that the shutter curtain, as a whole, may be roll on and off a single drum. Hence, the shutter curtain
20 may provide a simple and sleek configuration which may be effective in providing insulation while maintaining the simple operation of being rolled and unrolled using a single drum.

[000135] While the invention has been particularly shown and described with reference
25 to specific embodiments, it should be understood by those skilled in the art that various changes, modification, variation in form and detail may be made therein without departing from the scope of the invention as defined by the appended claims. The scope of the invention is thus indicated by the appended claims and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced.

Claims

1. A shutter curtain comprising:

at least two primary slats pivotally interlocked in a longitudinal-edge-to-longitudinal-edge arrangement one after another, wherein each of the at least two primary slats comprises an elongated primary-slat-body having a longitudinal axis, the elongated primary-slat-body being integrally formed with a first interlockable longitudinal edge portion and a second interlockable longitudinal edge portion, the first interlockable longitudinal edge portion and the second interlockable longitudinal edge portion of the elongated primary-slat-body being opposite each other on opposite sides of the longitudinal axis of the elongated primary-slat-body, wherein the first interlockable longitudinal edge portion of the elongated primary-slat-body of a first primary slat of the at least two primary slats is pivotally interlocked with the second interlockable longitudinal edge portion of the elongated primary-slat-body of a second primary slat of the at least two primary slats to form a pivotable joint between the at least two primary slats, wherein a pivot axis of the pivotable joint is parallel to the longitudinal axis of the elongated primary-slat-body;

at least two secondary slats unconnected from each other; and

at least two thermal insulating units respectively connected between the at least two primary slats and the at least two secondary slats to hold apart each of the at least two primary slats and a corresponding one of the at least two secondary slats in a manner so as to thermally insulate said primary slat from said secondary slat.

2. The shutter curtain as claimed in claim 1, wherein each of the at least two secondary slats comprises an elongated secondary-slat-body having a longitudinal axis, the elongated secondary-slat-body being integrally formed with a first engagement longitudinal portion and a second engagement longitudinal portion, the first engagement longitudinal portion and the second engagement longitudinal portion of the elongated secondary-slat-body being opposite each other on opposite sides of the longitudinal axis of the elongated secondary-slat-body, wherein the elongated secondary-slat-body of a first secondary slat of the at least two secondary slats is stackable on the elongated secondary-slat-body of a second secondary slat of the at least two secondary slats with the first engagement longitudinal portion of the elongated secondary-slat-body of the first

secondary slat in engagement with the second engagement longitudinal portion of the elongated secondary-slat-body of the second secondary slat.

3. The shutter curtain as claimed in claim 2, wherein the engagement between the first engagement longitudinal portion of the elongated secondary-slat-body of the first secondary slat and the second engagement longitudinal portion of the elongated secondary-slat-body of the second secondary slat is a mesh-type engagement which forms a separable lap joint or a separable overlap joint or a separable tongue-and-groove joint.

4. The shutter curtain as claimed in claim 2 or 3, wherein a cross-section of the first engagement longitudinal portion of the elongated secondary-slat-body of each of the at least two secondary slats comprises an insert profile and a cross-section of the second engagement longitudinal portion of the elongated secondary-slat-body of each of the at least two secondary slats comprises a complementary recess profile.

5. The shutter curtain as claimed in any one of claims 2 to 4, wherein the elongated secondary-slat-body of each of the at least two secondary slats further comprises a retaining arrangement to hold a first portion of a corresponding one of the at least two thermal insulating units to the elongated secondary-slat-body.

6. The shutter curtain as claimed in claim 5, wherein the retaining arrangement of the elongated secondary-slat-body comprises a pair of opposing lip formations extending towards each other from opposite longitudinal edge portions of the elongated secondary-slat-body.

7. The shutter curtain as claimed in claim 6, wherein each of the pair of opposing lip formations of the retaining arrangement of the elongated secondary-slat-body is formed by folding over a corresponding segment of the elongated secondary-slat-body.

8. The shutter curtain as claimed in claim 6 or 7, wherein the first portion of the corresponding one of the at least two thermal insulating units comprises a pair of transverse protrusions extending in opposite directions, the pair of transverse protrusions being respectively in engagement with the pair of opposing lip formations of the retaining

arrangement of the elongated secondary-slat-body for connecting the first portion of the corresponding one of the at least two thermal insulating units to the elongated secondary-slat-body.

9. The shutter curtain as claimed in claim 6 or 7,

wherein each of the at least two secondary slats further comprises a secondary-slat-support-frame coupled to the elongated secondary-slat-body, the secondary-slat-support-frame having a pair of grooves directed away from each other along two opposite edge portions of the secondary-slat-support-frame, and a recess portion between the two opposite edge portions of the secondary-slat-support-frame,

wherein the secondary-slat-support-frame is coupled to the elongated secondary-slat-body with the pair of grooves of the secondary-slat-support-frame respectively slide over the pair of opposing lip formations of the elongated secondary-slat-body,

wherein the first portion of the corresponding one of the at least two thermal insulating units is inserted and retained in the recess portion of the secondary-slat-support-frame.

10. The shutter curtain as claimed in claim 9, wherein the secondary-slat-support-frame is made from a sheet of material roll-formed to bend the two opposite edge portions of the secondary-slat-support-frame to form the pair of grooves and to bend a region between the two opposite edge portions of the secondary-slat-support-frame to form an open channel defining the recess portion.

11. The shutter curtain as claimed in any one of claims 5 to 10, wherein the elongated secondary-slat-body is made from a sheet of material roll-formed to integrally form the first engagement longitudinal portion, the second engagement longitudinal portion, and the retaining arrangement.

12. The shutter curtain as claimed in claim any one of claims 1 to 10, wherein the elongated primary-slat-body of each of the at least two primary slats further comprises a retaining arrangement to hold a second portion of a corresponding one of the at least two thermal insulating units to the elongated primary-slat-body.

13. The shutter curtain as claimed in claim 12, wherein the retaining arrangement of the elongated primary-slat-body comprises a pair of opposing lip formations extending towards each other respectively from the first interlockable longitudinal edge portion and the second interlockable longitudinal edge portion of the elongated primary-slat-body.

14. The shutter curtain as claimed in claim 13, wherein each of the pair of opposing lip formations of the retaining arrangement of the elongated primary-slat-body is formed by folding over a corresponding segment of the elongated secondary-slat-body.

15. The shutter curtain as claimed in claim 13 or 14, wherein the second portion of the corresponding one of the at least two thermal insulating units comprises a pair of transverse protrusions extending in opposite directions, the pair of transverse protrusions being respectively in engagement with the pair of opposing lip formations of the retaining arrangement of the elongated primary-slat-body for connecting the second portion of the corresponding one of the at least two thermal insulating units to the elongated primary-slat-body.

16. The shutter curtain as claimed in claim 13 or 14,

wherein each of the at least two primary slats further comprises a primary-slat-support-frame coupled to the elongated primary-slat-body, the primary-slat-support-frame having a pair of grooves directed away from each other along two opposite edge portions of the primary-slat-support-frame, and a recess portion between the two opposite edge portions of the primary-slat-support-frame,

wherein the primary-slat-support-frame is coupled to the elongated primary-slat-body with the pair of grooves of the primary-slat-support-frame respectively slide over the pair of opposing lip formations of the elongated primary-slat-body,

wherein the second portion of the corresponding one of the at least two thermal insulating units is inserted and retained in the recess portion of the primary-slat-support-frame.

17. The shutter curtain as claimed in claim 16, wherein the primary-slat-support-frame is made from a sheet of material roll-formed to bend the two opposite edge portions of the primary-slat-support-frame to form the pair of grooves and to bend a region between the

two opposite edge portions of the primary-slat-support-frame to form an open channel defining the recess portion.

18. The shutter curtain as claimed in any one of claims 12 to 17, wherein the elongated primary-slat-body is made from a sheet of material roll-formed to integrally form the first interlockable longitudinal edge portion, the second interlockable longitudinal edge portion, and the retaining arrangement.

19. The shutter curtain as claimed in any one of claims 1 to 18, further comprising insulating material inserted between each of the at least two primary slats and the corresponding one of the at least two secondary slats, wherein the elongated secondary-slat-body of each of the at least two secondary slats further comprises an auxiliary retaining arrangement to keep the insulating material in place.

20. A roller shutter, comprising
a drum; and
the shutter curtain according to any one of claims 1 to 19, wherein the shutter curtain is attached to the drum in a manner so as to be capable of being rolled on and off the drum when the drum is being rotated.