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METHOD AND APPARATUS FOR SECURE STORAGE AND HANDLING OF ELONGATE OBJECTS

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Field of the Invention

The present invention relates to an article and method for the secure storage, handling and transportation of pipe or other relatively rigid, elongate objects.

Background of the Invention

Pipe is used in countless applications in a wide variety of industries. In one application, "drill pipe" is used for drilling bore holes for crude oil recovery. Such drilling requires interconnecting many sections of drill pipe to form a "drill string" that may ultimately extend for more than one thousand feet under ground or under water.

As drill pipe sections are nominally 31 feet long and very heavy, their transportation to an offshore drilling platform can be costly and hazardous. Such transportation requires bundling the pipe at a land-based supply location, loading it onto a truck, delivering it to a dock, loading it onto a marine vessel, transporting it to the offshore platform and then unloading it for storage or use. Little can be done to circumvent such handling steps. But there is room for significant improvement in the apparatuses and methods that are used to secure such drill pipe for storage, handling and transport.

The method/apparatus most commonly employed for lifting and transporting drill pipe is to bundle the pipe with "choking slings." The bundled pipe is then lifted onto a truck, vessel, *etc.* using a crane. API Recommended Practices substantially limit the amount of pipe that can be handled per lift using such slings. As a result, the overall number of handling steps rapidly increase as multiple lifts are required at each stage as the pipe travels from supplier to platform. Such increased handling increases costs (*e.g.*, labor costs, crane charges, *etc.*). Moreover, when tension on a loaded sling is relaxed, such as when the sling and pipes are deposited on a surface of a truck, marine vessel or drilling platform, the pipes are free to move in an uncontrolled manner presenting a risk of injury.

Specialized pipe storage/transportation apparatuses have been developed. Some of such apparatuses include spaced upright members that receive a plurality of cross members. Pipe sections are laid between such cross members (hereinafter "packing members") in an attempt to restrain such pipe segments from moving. Under harsh conditions, such apparatuses are often incapable of preventing slippage/movement of pipe. For example, the deck of a marine vessel

may pitch ten to fifteen degrees in rough seas, thereby "tilting" such storage apparatuses. Under those conditions, there may be insufficient contact (*i.e.*, frictional surface) between the pipe and packing members to prevent pipe slippage causing a potentially hazardous situation.

In one prior art storage/transportation apparatus, the pipe-receiving surfaces of packing members that are used to constrain pipe are not flat, but rather cycloid-shaped, as depicted in FIG. 1. Each pipe-receiving surface of packing member **100** includes a plurality of arc-shaped regions **102A , 102B** (that collectively define the cycloid-shaped profile). Each of such regions **102A, 102B** are configured to receive a "matched" diameter section of pipe **104** (two pipe sections **104** are depicted in FIG. 1). Two such packing members **100** are used to sandwich pipe sections **104**. A "u-shaped" frame receives a plurality of such packing members **100** stacked one above the next so that multiple rows of pipe can be constrained.

In comparison with a prior art packing member having a flat pipe-receiving surface, arc-shaped regions **102** increase surface contact with the constrained pipe. The increased surface contact decreases the likelihood of pipe slippage.

As indicated above, packing member **100** is designed to fit a specific pipe diameter (*e.g.*, 5-inch diameter or 4½-inch diameter, *etc.*) as a function of the radius of curvature of arc-shaped regions **102**. As such, a given packing member **100** is usable with *only one size of pipe*. Thus, if a load of pipe includes, for example, 3-inch, 4½-inch and 5-inch diameter pipe, correspondingly-sized packing members are required to receive such pipe. Such specificity disadvantageously increases costs and presents the possibility that appropriately-sized packing members will not be available when needed.

As such, there is a need for an improved packing member, and a storage/transportation apparatus incorporating such a packing member, that is effective in restraining movement of elongate objects yet can cost effectively accommodate multiple object diameters.

Summary of the Invention

In some embodiments, an improved packing member includes a rigid interior portion enclosed by a resilient exterior portion. The exterior portion has a physical adaptation that generates a force in response and in opposition to the motion of an elongate object thereover. The generated force advantageously *increases* in magnitude as the object moves over a packing member.

In further embodiments, an article for constraining elongate objects includes a frame that receives the improved packing members. In the illustrated embodiments, the frame comprises two vertically oriented side portions that depend from a base. The frame advantageously

includes a variable positioning element, which, in the illustrated embodiments, is a slot running the length of each of the vertical side portions. Each slot receives a tab/projection that depends from each end of the packing member. The packing members are freely positionable along the length of the slots.

The force-generating design of the packing member, and the variable positioning element enables the present article to handle multiple object diameters/geometries. For restraining very long or heavy objects, two or more frames can be rigidly interconnected.

Brief Description of the Drawings

FIG. 1 depicts a cycloid-shaped cross member used for constraining cargo in the prior art.

FIG. 2 depicts an article for handling elongate objects in accordance with an illustrated embodiment of the present invention.

FIG. 3 depicts two illustrative packing members constraining sections of pipe.

FIG. 4 depicts the present packing members constraining several rows of pipe sections within in an illustrative frame, and further depicts an illustrative embodiment of a compressing arrangement for use in conjunction with the packing members.

FIG. 5 depicts a second illustrative embodiment of a compressing arrangement for use in conjunction with the present packing members and frame.

FIG. 6 depicts an apparatus wherein two of the frames of FIG. 2 are interconnected.

FIG. 7 depicts an illustrative non-uniform object-receiving surface of an exterior portion of the packing member in accordance with the present teachings.

FIG. 8 depicts a section of pipe moving across the exterior portion of the packing member shown in FIG. 7.

FIG. 9 depicts a second embodiment of a packing member in accordance with the present invention.

FIG. 10 depicts a perspective view of the packing member of FIG. 9.

FIG. 11 depicts a third embodiment of the present packing member.

Detailed Description

The illustrated embodiments of the present invention are particularly useful for storing and transporting relatively rigid, cylindrical, elongate objects, such as drill pipe. Such embodiments are also useful for storing and transporting relatively rigid, flat, elongate objects or elongate objects having a different geometry or cross-sectional shape.

FIG. 2 depicts storage and transport frame **200** in accordance with an illustrated embodiment of the present invention. Illustrative frame **200** is generally "u-shaped" and comprises two spaced, vertically-oriented side portions **220A, 220B** that depend from base **210**. In one embodiment, side portions **220A, 220B** and base **210** are "discrete" elements (*e.g.*, individually-fabricated elements) that are attached (*e.g.*, bolted, welded, *etc.*) to form frame **200**.

Frame **200** has one or more physical adaptations that allow it to receive cross members **230** that, in use, are placed in underlying and overlying relation to elongate objects (*e.g.*, drill pipe), thereby "sandwiching" such objects. FIG. 3 depicts two cross members **230** sandwiching pipe sections **308** (frame **200** omitted for clarity) to restrain such pipe sections from moving. The overlying cross member contacts pipe sections **308** at upper contact surface **336** and the underlying cross member contacts pipe sections **308** at lower contact surface **338**. In conjunction with other features of the prevent invention, cross members **230** are capable of substantially immobilizing such sandwiched objects.

In one embodiment, a physical adaptation by which frame **200** receives cross members **230** (hereinafter referred to as "packing members") advantageously comprises a variable positioning element. Through such a variable positioning element, packing members **230** are freely positionable in a vertical direction (*i.e.*, along axis **2-2**) within frame **200** (hereinafter referred to as simply "variably positionable" or "variable positioning").

In one embodiment, the variable positioning element is realized by an arrangement that receives packing members **230** in sliding engagement. In the embodiment illustrated in FIG. 2, such an arrangement comprises slot or channel **222A, 222B** that is formed within respective side portions **220A** and **220B**. Channels **222A, 222B** receive respective tabs/projections **232A, 232B** of each packing member **230**. When so engaged by channels **222A** and **222B**, packing members **230** are restrained from moving except in a "vertical" direction along long axis **2-2** of side portions **220A** and **220B**.

Such variable positioning advantageously enables illustrative frame **200** and packing member **230** to store/restrain a collection of objects characterized by multiple object diameters/geometries, as is illustrated in FIG. 4.

FIG. 4 depicts the present frame and packing members receiving a first row **416** of objects having a first diameter and a second row **418** of objects having a second diameter different than the first diameter. Objects in first row **416** are restrained by packing members 230_A and 230_B, and objects in second row **418** are restrained by packing members 230_B and 230_C.

In the above-described manner, illustrated embodiments of the present frame and packing members can thus accommodate multiple object diameters/geometries on a row-by-row basis. It must be understood, however, that within a given row (*i.e.*, between two given packing members), objects should have a uniform diameter (geometry) so that adequate contact between the packing members and each constrained object is assured.

In addition to providing utility for restraining a collection of objects characterized by multiple object diameters/geometries, the variable positioning means of the present invention allows for partial utilization of the packing space available within frame **200**. Such partial utilization is depicted in FIG. 4, wherein room for additional rows of objects is available. Alternatively, the frame can be fully utilized, wherein additional rows of objects and additional packing members are loaded above packing member 230_C until reaching the top of side portions **220A, 220B**.

Referring again to FIG. 3, to aid in securely restraining pipe sections **308**, exterior portion **234** of packing members **230** is advantageously resilient. Due to such resilience, as the upper and lower contact surfaces **336, 338** of the overlying and underlying packing members are urged, via clamping force **306**, toward pipe sections **308**, such surfaces partially deform around the pipe sections. Such deformation increases surface contact between the packing member and the constrained objects (*e.g.*, pipe sections). Such increased surface contact increases the constraining force on the constrained objects relative to a flat, non-deforming packing member.

As described further later in this specification, in some embodiments, exterior portion **234** is realized as an extruded or molded elastomer. Such an elastomeric exterior advantageously encloses a rigid (*e.g.*, steel) inner portion (not shown in FIG. 3) that resists deformation along vertical, lateral and longitudinal axes.

In accordance with the present teachings, and in some embodiments of the present invention, exterior portion **234** has one or more physical adaptations that generate a restraining force in response to motion of an elongate object thereover. The elongate object's motion can be due, for example, to the pitching of the deck of a vessel in rough seas. The generated force opposes motion of the object and advantageously *increases* in magnitude as the object moves across a packing member. The increasing resistive force rapidly overcomes the force urging the object to motion, thereby stopping such motion. Further description of such physical adaptations is provided later in this Specification.

Drill pipe and other objects are very heavy and will cause packing members **230** to deform to some extent without an additional externally applied clamping force. Of course, the uppermost packing member is not subjected to an overlying layer of objects. Therefore, to constrain objects in an uppermost row within a frame (and, as a practical matter, to secure all objects in the frame), a clamping/compressing force is applied to the packing members in addition to the compressing force supplied by the weight of the constrained objects.

The clamping/compressing force can be suitably applied via a variety of mechanisms/arrangements. In a first embodiment depicted in FIG. 4, lock-down member **440** is received by frame **200** on top of the uppermost packing member (*i.e.*, packing member 230_C in FIG. 4). In the illustrated embodiment, projections **444A** and **444B** are received by respective slots **222A** and **222B** in the side portions of the frame. In one embodiment, the upper surface of lock-down member **440** includes two pairs of ridges **448** that define grooves **442**. Such grooves **442** each receive a strong cable, chain, strap or like element **450** that is placed under tension to force lock-down member **440** downwardly towards uppermost packing member 230_C applying a compressive or clamping force thereto. For clarity, only one chain **450** is depicted in FIG. 4.

In one embodiment, each chain **450** is fastened, at one end, to lugs **452** disposed near the bottom of each side portion **220A, 220B**. The other end of chain **450** is connected to a tensioning mechanism (not shown), such as, for example, a well-known ratchet tensioning mechanism. The ratchet tensioning mechanism is also secured to a further lug (not shown) on the opposite side of frame **200** from lugs **452**. In well-known fashion, the ratchet tensioning mechanism is tightened thereby placing chain **450** in tension to exert a downwardly-directed force on lock-down member **440**, and, hence, a clamping force on the underlying packing members and constrained objects.

In a second embodiment depicted in FIG. 5, the clamping/compressing force is applied via lock-down rod **540**. In particular, projections **532A** and **532B** (for engaging the slot in side members **220A** and **220B**) depending from the packing members each include a hole **535**. Holes **535** receive lock-down rod **540**. The lock-down rod is received, at its lower end, by receiver hole **552** in base **210** of frame **200**. The lock-down rod is advantageously threaded to receive nut **542**. Nut **542** is drawn down on lock-down rod **540**, compressing or clamping the packing members and constrained objects.

For clarity of presentation, only one threaded rod **540** is shown in FIG. 5 (depicted as being engaged by hole **535** in projection **532B** at the "right" side of the packing members). It will be understood that such a threaded rod advantageously engages holes **535** in the projections on each end of the packing members.

The illustrative arrangements described above, hereinafter referred to as a "compressing arrangement," can be used for securing frames that are either partially or fully loaded with

elongate objects. The described compressing arrangements can be used independently of each other or in cooperation with one another to secure objects within frame **200**.

It is advantageous for at least two frames 200 to be used cooperatively to restrain relatively long objects. In such embodiments, it is advantageous, but not necessary, to interconnect such frames. FIG. 6 depicts an illustrative multi-frame apparatus **600** in accordance with the present teachings wherein two frames **200** are interconnected to facilitate the storage and transportation of long objects, such as, for example, 31-feet-long drill pipe sections.

In the illustrated embodiment, frames **200** are joined via two connector members **660A** and **660B**. Such connector members are advantageously joined to frames **200** near base **210**. Connector members **660A** and **660B** and frames 200 may suitably be provided with flanges that align for bolting, or the connector members and frames can be welded together. In a further embodiment (not depicted), frames **200** are adapted to slidingly engage connector members **660A** and **660B** such that they can be variably positioned along the length of the connector members. Once positioned, frames 200 are then tightened down, bolted, *etc.*, to the connector members.

In the embodiment depicted in FIG. 6, the attachment of connector members **660A** and **660B** to frames **200** creates a generally rectangular base between the two frames. Such an arrangement provides a rigidity to apparatus **600** that is not present when multiple frames are used in the absence of such interconnections. Moreover, transportation of constrained objects is facilitated by apparatus **600** as it is advantageously provided with lifting lugs or "padeyes" (not depicted) that can receive sling(s) that allow apparatus **600** to be readily lifted by a crane, *etc.*

In some embodiments, apparatus **600** includes forklift receivers **662A** and **662B** for receiving prongs of a forklift (not shown) to facilitate transport of apparatus **600**. Moreover, a stacking lug **664** that is located on top of each side portion **220A, 220B** of each frame **200** (only one is depicted in FIG. 6), is received by a socket (not shown) appropriately located in base **210** of each frame **200**. Such stacking lugs and sockets allow apparatuses **600** to be stacked one above another.

In use, elongate objects (*e.g.*, drill pipe, *etc.*) of like diameter/geometry are loaded onto a lowermost packing member. The weight of such objects deforms the resilient exterior of the lowermost packing member. The lowermost packing member can be configured differently from other packing members since only the upper surface of the lowermost packing member is in contact with pipe.

Objects are laid substantially completely across the packing member, as depicted in FIG. 4. A second packing member is then engaged to the frame by, for example, positioning the projections **232A, 232B** within channels **222A, 222B** of side portions of each frame (assuming a

multiple frame apparatus such as illustrative apparatus **600**). The second packing member is slid down the channels to rest on top of the layer (*e.g.*, layer **416** in FIG. 4) of drill pipe sections. A further layer of drill pipe of a uniform diameter is then loaded and the process is continued until the desired amount of drill pipe is loaded or until the frame is full. A final packing member is engaged to the channel and positioned to abut the uppermost layer of drill pipe.

A compressing arrangement is then engaged to the frame and applied such that the various drill pipe sections, and the packing members that sandwich them, are clamped together such that a compressive force is exerted thereon. In one embodiment, the compressing arrangement comprises top member **440**, chains **450** and a tensioning mechanism (as in the embodiment depicted in FIG. 4). In another embodiment, the compressing arrangement comprises threaded rod **540** and nut **542** (as in the embodiment depicted in FIG. 5). Other compressing arrangements as will occur to those skilled in the art may suitably be used in conjunction with the present invention.

A space/gap **IFS** between frames **200** (hereinafter "inter-frame spacing") in illustrative apparatus **600** is primarily dependent upon the length and material properties of the elongate object being constrained. Suitable inter-frame spacing **IFS** is readily determined by simple experimentation. In particular, it will be appreciated that for a two-frame apparatus such as apparatus **600**, as inter-frame spacing **IFS** is reduced, so is the cost and weight of the apparatus **600**. But, the decrease in inter-frame spacing **IFS** is accompanied by an increase in the portion of the elongate object that will be cantilevered beyond each frame. At some point, the portion of the elongate object that is cantilevered may be determined to be "excessive." Such a determination may be made, for example, by supporting the object at various test locations and observing the physical response of the object (*e.g.*, flexion, sagging, *etc.*). Additionally, x-rays can be taken to ascertain if there is any effect on material integrity (*e.g.*, stress fractures, *etc.*) due to any observed flexion, *etc.*

For an apparatus having two interconnected frames, such as apparatus **600**, an inter-frame spacing **IFS** of about fifteen feet has been found to be suitable for carrying steel drill pipe having a nominal length of 31 feet. In such an apparatus, drill pipe sections are advantageously positioned such that about one-quarter of the length of each pipe section is cantilevered beyond each frame, leaving about one-half the length of the pipe section between the two frames.

In other embodiments (not shown), a multi-frame apparatus in accordance with the present teachings has more than two frames. Such additional frames may be required, for example, to support elongate objects having a length greater than 31 feet or objects that are particularly heavy, as may result from a particularly dense material of construction, a large

diameter/pipe-wall thickness, *etc.* Again, the number of frames required and inter-frame spacing IFS is readily determined by simple experimentation.

Frame width may be selected, for example, based on commercial considerations. In one embodiment, maximum frame width is advantageously 42 inches. This width allows two of such frames (or two multi-frame apparatuses) to be located side-by-side on a flat-bed truck (while complying with rules for vehicle width on the roads).

As previously indicated, in some embodiments, a force that opposes motion of an elongate object is generated as that elongate object begins moving over the exterior portion **234** of a packing member. In preferred embodiments, the generated force *increases* in magnitude with continued movement of the object.

In some embodiments, the force is generated by one or more physical adaptations of the resilient exterior portion itself. In the illustrated embodiments, the force-generating physical adaptation of the resilient exterior portion comprises a configuration that results in a regionally-variable compression of the resilient exterior portion as an object moves thereover. In response to such regionally-variable compression, the resilient exterior portion exerts a force against the constrained (but moving) object.

In the illustrated embodiments, the regionally variable compression-causing configuration comprises a non-uniform object-receiving surface. As used herein, the phrase "non-uniform object-receiving surface" is meant to indicate a contact surface or surface profile that is characterized by one or more features that, collectively, disrupt the uniformity of the contact surface. Such a non-uniform object-receiving surface is to be contrasted with a relatively featureless/smooth surface, such as the curved, but otherwise featureless pipe-receiving surface of prior art packing member **100** depicted in FIG. 1.

An illustrative embodiment of a non-uniform object-receiving surface suitable for generating such force is depicted in FIG. 7, which shows a cross-section of a packing member **730**. FIG. 8 depicts a response of exterior portion **734** of packing member **730** to the movement of pipe **808** along a direction **806**.

Packing member **730** includes a rigid interior portion **736** that is advantageously resistant to motion in all directions (*i.e.*, along three axes). Interior portion **736** is encased by resilient exterior portion **734**. In one embodiment, illustrative exterior portion **734** comprises an elastomer that is bonded, such as via thermal bonding, to interior portion **736**. Exterior portion **734** can be formed by any suitable method, such as, for example, molding, extrusion and the like.

The surface profile of illustrative exterior portion **734** includes inclined lobes **770A**, **770B**, **770C** and **770D**, asymmetric protrusions **772A**, **772B**, **772C** and **772D**, and symmetric

protrusions 774A, 774B, 774C and 774D. Such lobes, asymmetric protrusions and symmetric protrusions are illustrative of features that define a non-uniform object-receiving surface.

In the illustrated embodiment, the surface profile of exterior portion 734 is symmetric with respect to vertical symmetry axis 3-3 and symmetric with respect to lateral symmetry axis 4-4. The vertical profile of exterior portion 734 (*i.e.*, the profile across vertical symmetry axis 3-3) is advantageously configured to allow vertical (*i.e.*, parallel to axis 4-4) displacement of exterior portion 734 with increasing (vertical) compression thereof.

As an example of a configuration suitable for providing vertical displacement under compression, exterior portion 734 includes "undercut" region 778 between upper lobes 770A (770B) and lower lobes 770C (770D). Under sufficient vertical compression, inclined lobes 770A and 770C (and 770B and 770D) are driven towards one another and may in fact even contact one another as a function of the magnitude of the compressing force. Such vertical displacement is thus facilitated via undercut region 778.

In some embodiments, the profile of exterior portion 734 is advantageously configured to allow lateral (*i.e.*, parallel to axis 3-3) displacement of surface features (*e.g.*, lobes, protrusions, *etc.*) of exterior portion 734 as the exterior portion is subjected to compression or to a force having both vertically and laterally-directed components. The lateral separation or spacing between the lobes (*e.g.*, lobes 770A and 770B) allows for lateral displacement of the lobes when they are under compression. Similarly, the lateral spacing between adjacent asymmetric and symmetric protrusions (*e.g.*, protrusions 772A and 774A) allows for lateral displacement of the asymmetric protrusion under compression. Another way to facilitate such lateral displacement is to "undercut" a surface feature.

Thus, under compression, such as is caused by the weight of a constrained object and/or a secondary compressing force, the various lobes and protrusions deform (both above and below vertical symmetry axis 3-3). The deformation caused by such compression exerts a force or pressure *against* the constrained object.

More particularly, compressive forces are resisted by the resilient material that comprises exterior portion 734. The resistance offered by the resilient material manifests as a force that is exerted against the object. When constrained by overlying and underlying packing members, and assuming that the friction coefficient between exterior portion 734 and the constrained object is sufficient, the generated force opposes any lateral motion and/or longitudinal motion (*i.e.*, motion that is "into the page" in FIGS. 7 and 8) of the constrained object.

The magnitude of the force/pressure exerted against the object varies with the thickness of exterior portion 734 and with the compressing force applied thereto. In the illustrated embodiment, the thickness of exterior portion 734 is at a maximum along axes 5-5 and 6-6. As

such, for that embodiment, the maximum force is exerted against a constrained object along such axes.

In some embodiments, such as the one depicted in FIG. 7, lobes **770A – 770D** and asymmetric protrusions **772A – 772D** are configured to exert an *increasing* resistance to oppose lateral movement of an object. Consider FIG. 8, which depicts an object **808**, such as a pipe, moving along the direction **806** (*i.e.*, toward the right in FIG. 8).

As object **808** moves in direction **806** over inclined upper surface **776** of lobe **770A**, exterior portion **734** thickens, reaching a maximum thickness along axis **5-5**. As the exterior portion thickens, the force exerted by the exterior portion **734** against object **808** increases. Moreover, as lobe **770A** is compressed and/or forced in direction **806**, the downwardly-sloping interior upright wall of lobe **770A** (*i.e.*, the portion of lobe **770A** that is to the right of axis **5-5**) will compress and exert a force against the object. The greater the compressing force, the greater the force exerted by the exterior portion against the object. The exerted force will have a component directed towards the left (in FIG. 8) thereby resisting movement of the object.

In asymmetric protrusion **772B**, the increase in resistive force is due to the off-centered peak **780**. As a heavy object moves in the direction **806** over exterior portion **734**, peak **780** of protrusion **772B** are forced downwardly and to the right. The resilient material comprising exterior portion **734** resists such compression, exerting a force on object **808**.

In the illustrated embodiment, the configuration of the lobes and asymmetric protrusions on one side of lateral symmetry axis **4-4** is "opposed" to (*i.e.*, the mirror image of) the configuration of the lobes and asymmetric protrusions on the other side of the lateral symmetry axis. That is, while lobe **770A** "leans" to the left, lobe **770B** leans to the right. Similarly, while asymmetric protrusion **772A** "leans" to the right, asymmetric protrusion **772B** leans to the left. With such an arrangement, exterior portion **734** is capable of resisting movement of an object that is moving in either direction (*i.e.*, to the left or to the right in FIG. 8).

In some embodiments, a high-friction material is disposed on contact surfaces of exterior portion **734** (*e.g.*, the appropriate surfaces of lobes **770A – 770D**, *etc.*) to aid in reducing slippage of a constrained object, Suitable high-friction materials include, without limitation, natural or man-made crystalline particles (*e.g.*, sand, coal slag, aluminum oxide, *etc.*). Note that the presence of such high-friction materials on an otherwise featureless surface will not define a "non-uniform object-receiving surface," as that phrase is used herein.

It will be understood that in other embodiments, other packing members having other arrangements of features defining other non-uniform object receiving surfaces (*i.e.*, other than the profiles depicted in FIG. 7) can be used to generate a force(s) that opposes motion of a constrained but moving elongate object. Indeed, two of such alternative embodiments are

depicted in FIGS. 9-11. The embodiment depicted in FIG. 7 will therefore be considered representative or illustrative of several features or attributes that are advantageously manifested in preferred embodiments of the present packing members. Preferred packing members will incorporate one or more of such features, as were described above and summarized again below.

1. Some embodiments of preferred packing members will provide for vertical displacement of lobes or other features. This can be accomplished, for example, by "undercutting" (*see* above description) or otherwise providing a notch, recess or like indentation between the upper lobes and the lower lobes (*see, e.g.*, notches **980A,B** of FIG. 9 and notches **1080A,B** of FIG. 11).

2. Some embodiments of preferred packing members will provide for lateral displacement of lobes or other features, such as by providing a lateral separation between lobes (or between one lobe and other features). Such separation can be created, for example, using notches, gaps or channels (*see, e.g.*, channels **978A,B** of FIG. 9 and channels **1078A,B** of FIG. 11). Moreover, lateral displacement is facilitated by "undercutting" the lobe.

3. Some embodiments of preferred packing members will exhibit vertical symmetry (*e.g.*, symmetry across axis **3-3** in FIG. 7).

4. Some embodiments of preferred packing members will exhibit lateral symmetry (*e.g.*, symmetry across axis **4-4** in FIG. 7).

FIGS. 9-11 depict two additional embodiments of packing members that illustrate just two of the many other ways in which the preferred attributes/features described above can be implemented in accordance with the present invention.

FIG. 9 depicts an end view of a second embodiment of a non-uniform object-receiving surface suitable for generating a force to oppose motion of a constrained object. FIG. 10 shows a perspective view of packing member **930** having the features depicted in FIG. 9. As will be clear from the following description, the embodiment depicted in FIGS. 9 and 10 possesses all the preferred attributes described above.

Illustrative exterior portion **934** of packing member **930** includes, above vertical symmetry axis **7-7**, lobes **970A** and **970B** that flank central ridge **974**. In the illustrated embodiment, central ridge **974** has a concave surface **976**. Channel **978A** separates lobe **970A** and central ridge **974**. Similarly, channel **978B** separates lobe **970B** and central ridge **974**. Such channels allow for lateral displacement of exterior portion **934** in response to a compressive force.

Notches **980A** and **980B** are aligned with vertical symmetry axis 7-7. Such notches promote vertical displacement in response to a compressive force. Exterior portion **934** encloses interior portion **936**. Packing member **930** includes two tabs or protrusions (only tab/protrusion **932A** is depicted in FIGS. 9 and 10). One such tab depends from each end of packing member **930**. The tabs are used to engage packing member **930** to a frame (not shown in FIGS. 9 and 10), such as frame **200**. The profile and features below vertical symmetry axis 7-7 are advantageously identical to the profile and features that are described above.

A third embodiment of an illustrative non-uniform object-receiving surface suitable for generating a force to oppose motion of a constrained object is depicted, via an end view, in FIG. 11. Like the second embodiment, the third embodiment possesses all the preferred attributes described above.

Illustrative exterior portion **1034** of packing member **1030** includes, above vertical symmetry axis **8-8**, radiused lobes **1070A** and **1070B** that flank central ridge **1074**. In the illustrated embodiment, central ridge **1074** has a concave surface **1076**. Channel **1078A** separates lobe **1070A** and central ridge **1074**. Similarly, channel **1078B** separates lobe **1070B** and central ridge **1074**. Such channels allow for lateral displacement of exterior portion **1034** in response to a compressive force.

The receiving surface of lobes **1070A** and **1070B** are "inclined" by an angle towards horizontal or lateral symmetry axis **9-9**. As a result of such upward inclination, movement of a pipe (not shown) sliding over lobe **1070B** towards lobe **1070A** is resisted by face **1090A**, and, similarly, face **1090B** resists motion of a pipe sliding over lobe **1070A** towards lobe **1070B**.

Grooves **1088A** and **1088B**, which are disposed in respective lobes **1070A** and **1070B**, assist in restricting motion of pipe across exterior portion **1034** of packing member **1030**.

Notches **1080A** and **1080B** are aligned with vertical symmetry axis **8-8**. Such notches promote vertical displacement in response to a compressive force. Exterior portion **1034** encloses interior portion **1036**. Packing member **1030** includes two tabs or protrusions (only tab/protrusion **1032A** is depicted in FIG. 11). One of such tabs depends from each end of packing member **1030**. The tabs are used to engage the packing member to a frame (not shown in FIG. 11), such as frame **200**.

The profile and features below vertical symmetry axis 8-8 are advantageously identical to the profile and features that are described above.

In one embodiment, representative dimensions (in millimeters – mm) for exterior portion **1034** are as follows:

thickness T of exterior portion:	102 mm
width W of exterior portion:	134 mm
angle of inclination lobes (*e.g.*, lobe **1070B**):	6 degrees
width of grooves (*e.g.*, groove **1088A**):	9.5 mm
depth of grooves (*e.g.*, groove **1088A**):	2 mm
radius of surface **1086** of lobes (*e.g.*, lobe **1070B**):	38 mm
radius of surface **1082** of notches (*e.g.*, notch **1080A**):	7.5 mm
radius of surface **1076** of central ridges:	26.5 mm
radius of surface **1084** of channels (*e.g.*, channel **1078B**):	7.5 mm

It should now be clear that the present teachings concerning the configuration of the exterior portion of the packing member to generate a force (that advantageously increases) to oppose motion of a constrained object, can be implemented via a variety of arrangements. Those skilled in the art will be able to apply the principles of the present invention to develop other suitable non-uniform object-receiving surfaces. Simple testing can verify the efficacy of such other profiles.

In the illustrative embodiments depicted in FIGS. 7-11, the regionally variable compression-causing configuration comprises a non-uniform object-receiving surface. In other embodiments, the object-receiving surface is uniform, but the resilience/density of the material underlying the receiving surface varies regionally. Such underlying regional variations can cause the object-receiving surface of the resilient exterior portion to deform in a non-uniform manner such that forces generated therein are imparted to an overlying and moving object (*e.g.*, a pipe) to oppose motion thereof. In one embodiment, the resilience/density of the material can be locally varied by selectively removing material from (*e.g.*, forming holes or "pores" within) the resilent exterior portion.

CLAIMS:

1. An apparatus for handling a plurality of elongate objects, comprising a first packing member having a resilient exterior portion, wherein:

said resilient exterior portion has a non-uniform object-receiving surface,

said surface is capable of generating a force in response to, and in opposition to, movement of a first elongate object across said first packing member; and

the generated force increases in magnitude with movement of said first elongate object across said first packing member.

2. The apparatus of claim 1 wherein said non-uniform object-receiving surface comprises a regionally variable compressing-causing configuration that results in regional increases in compression of said resilient exterior portion as said first elongate object moves across said first packing member.

3. The apparatus of claim 1 or 2 wherein said non-uniform object-receiving surface is substantially linear.

4. The apparatus of claim 1, 2 or 3 wherein said first packing member comprises a rigid inner portion.

5. The apparatus of claim 2, 3 or 4 wherein said regionally variable compressing-causing configuration comprises:

first and second opposed lobes; and

a first region between said first and second opposed lobes that provides for lateral movement of said first and second opposed lobes.

The apparatus of claim 5 wherein:

a first half of said exterior portion is defined by said first and second opposed lobes and said first region; and

said first half of said exterior portion is above a vertical symmetry axis; and

further wherein said first packing member further comprises a second half of said exterior portion, wherein said second half is defined by third and fourth opposed lobes and a second region between said third and fourth opposed lobes that provides for lateral movement of said third and fourth opposed lobes.

The apparatus of claim 6 further comprising:

a first indentation disposed between said first lobe and said third lobe, wherein said first indentation provides for vertical movement of said first and third lobes; and

a second indentation disposed between said second lobe and said fourth lobe, wherein said second indentation provides for vertical movement of said second and said fourth lobes.

8. The apparatus of any preceding claim further comprising a first frame, wherein said first frame includes means for receiving and variably positioning said first packing member.

9. The apparatus of claim 8 wherein said first frame comprises:

a base having a first end and a second end; and

a first vertically-oriented member and a second vertically-oriented member, wherein:

said first vertically-oriented member depends from said first end of said base, and

said second vertically-oriented member depends from said second end of said base.

10. The apparatus of claim 9 wherein said means for receiving and variably positioning said first packing member comprises:

a first channel in said first vertically-oriented member, and

a second channel in said second vertically-oriented member, wherein said first channel and said second channel are disposed in facing sides of said respective first and said second vertically-oriented members so that:

said first channel receives a first end of said first packing member, and

said second channel receives a second end of said first packing member.

11. The apparatus of claim 8, 9 or 10 further comprising a compressing arrangement, wherein said compressing arrangement is coupled to said first frame to force said first elongate object against said first packing member

12. The apparatus of any of claims 8 to 11 further comprising a compressing arrangement and a second packing member, wherein:

said second packing member is received by said first frame;

said first elongate object is sandwiched at a first region along its length between said first and second packing members; and

said compressing arrangement is coupled to said first frame to force said second packing member against said first elongate object.

13. The apparatus of claim 12 further comprising a second frame, wherein:

said second frame includes means for receiving and variably positioning a third packing member and a fourth packing member;

said third and fourth packing members are positioned to sandwich said elongate object at a second region along its length; and

said second region is spaced apart from said first region.

14. The apparatus of claim 13 further comprising a connector for linking said first frame and said second frame, wherein said connector maintains said first frame and said second frame in spaced-apart relation to one another.

15. The apparatus of claim 14 wherein said connector is bolted to said first frame and said second frame.

16. The apparatus of any of claims 12 to 15 further comprising a third packing member, wherein:

said third packing member is received by said first frame;

said first, second and third packing members are identical;

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said first and second packing members are operable to sandwich a first elongate object, wherein said first elongate object has a first cross-sectional size;

said second and third packing members are operable to sandwich a second elongate object, wherein said second elongate object has a second cross-sectional size; and

said first cross-sectional size is different from said second cross-sectional size.

17. A packing member for use with an apparatus for handling a plurality of elongate objects, said packing member having a resilient exterior portion, wherein:

said resilient exterior portion has a non-uniform object-receiving surface, as herein before defined;

said surface is capable of generating a force in response to, and in opposition to, movement of a first elongate object across said first packing member; and

the generated force increases in magnitude with movement of said first elongate object across said first packing member.