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Carroccia et al.

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(54) **FORCE DAMPER**

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(73) Assignee: **On Top Safety, Inc.**, Cheektowaga, NY (US)

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Related U.S. Application Data

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A62B 35/04 (2006.01)
F16F 13/00 (2006.01)
A62B 35/00 (2006.01)

(52) **U.S. Cl.**

CPC ***A62B 35/04*** (2013.01); ***A62B 35/0068*** (2013.01); ***F16F 13/005*** (2013.01);

(Continued)

(58) **Field of Classification Search**

CPC F16F 13/005; F16F 13/04; F16F 7/003; F16F 7/12; F16F 2224/0208;

(Continued)

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Primary Examiner — Daniel P Cahn
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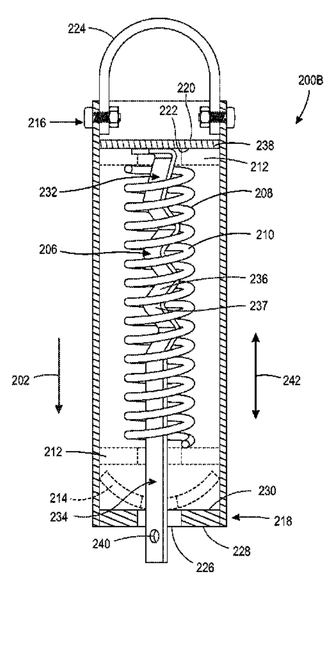
(74) *Attorney, Agent, or Firm* — Simpson & Simpson, PLLC

(57) **ABSTRACT**

A force damper arranged to progressively arrest a first force imparted by an object moving in a first direction is disclosed. The force damper includes a housing enclosure having a first housing end and a second housing end. The first housing end includes a first connection point, and the second housing end includes an opening. A driving member is disposed within the housing enclosure and includes a first shaft end, a second shaft end, and a shaft therebetween. The first shaft end includes a stop and the second shaft end includes a second connection point. A compressible member is disposed within the housing enclosure between the stop and the opening. The compressible member is formed from a material that at least partially undergoes plastic deformation when the first force is arrested and imparts a second force on the stop toward first housing end.

7 Claims, 21 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 62/610,786, filed on Dec. 27, 2017.

(52) **U.S. Cl.**
CPC . *F16F 2224/025* (2013.01); *F16F 2224/0208* (2013.01); *F16F 2224/0225* (2013.01)

(58) **Field of Classification Search**
CPC F16F 2224/0233; F16F 2224/0225; F16F 2224/025; F16F 2228/14; F16F 2230/0047; F16F 2232/08; A62B 35/04; A62B 35/0068
See application file for complete search history.

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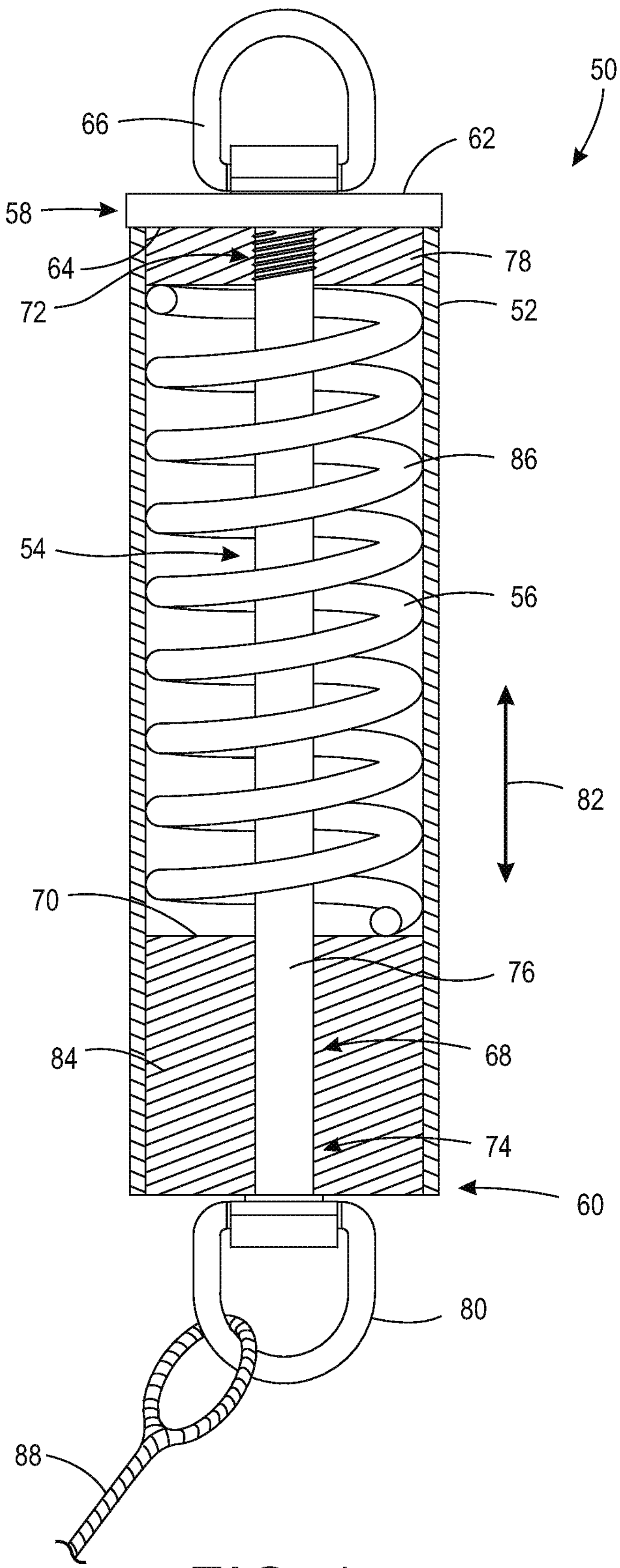

FIG. 1

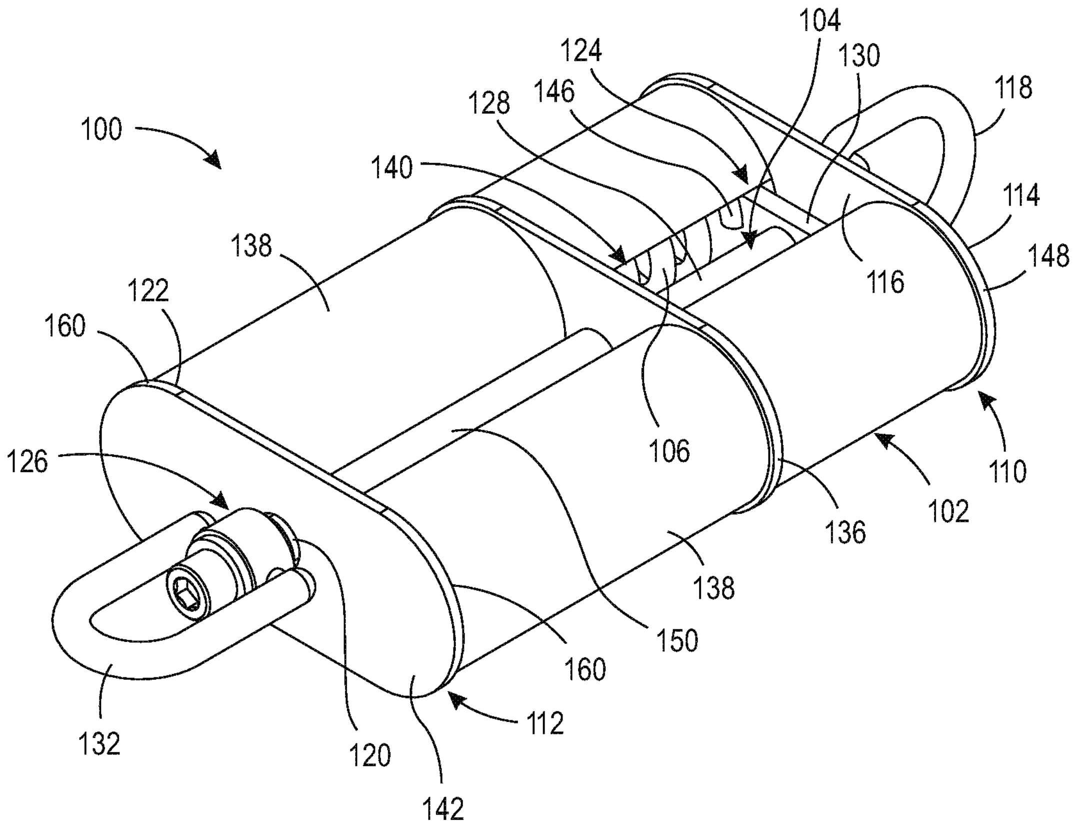
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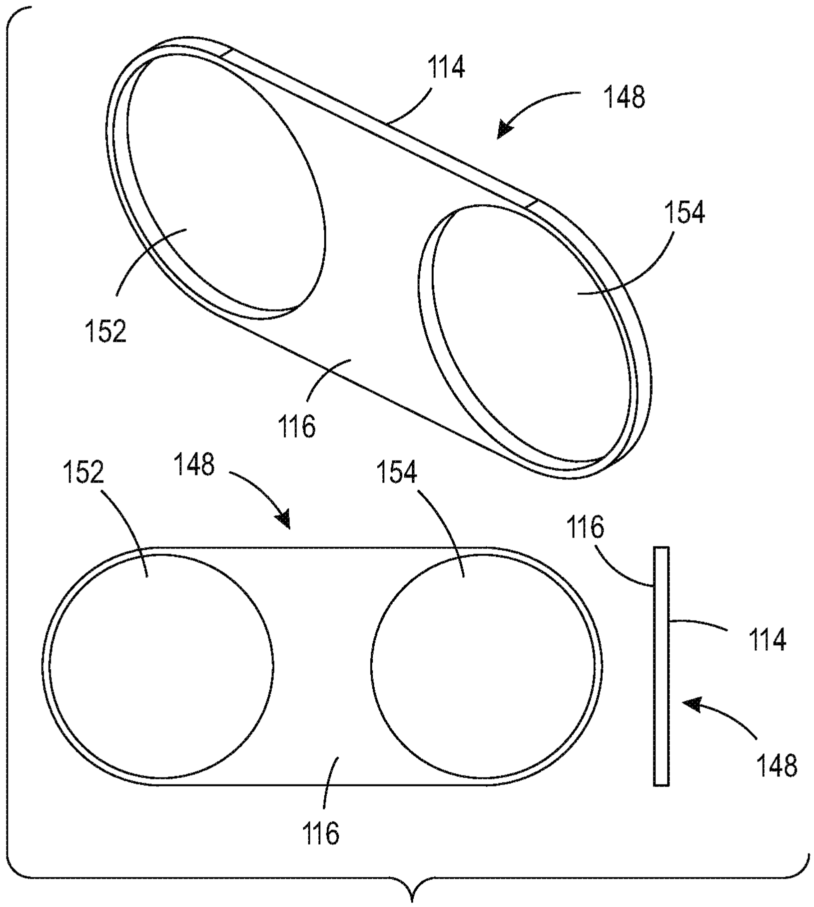
FIG. 2



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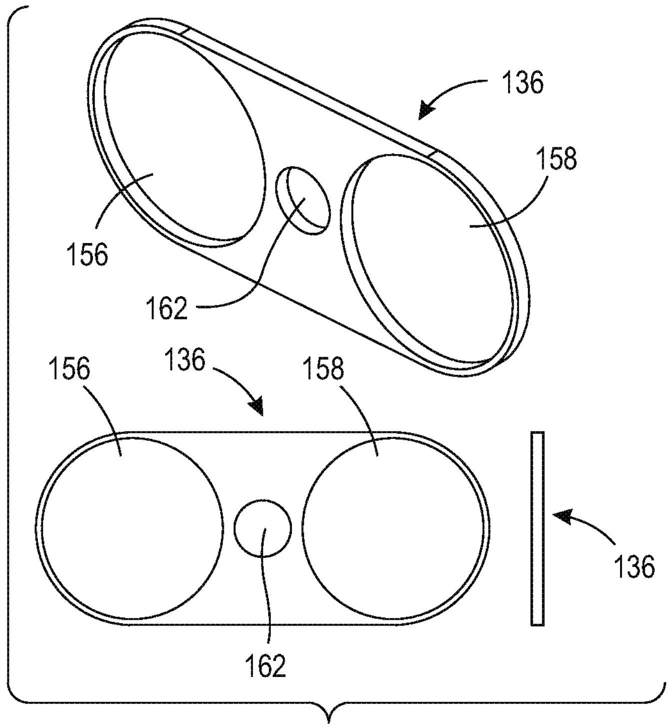
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FIG. 4

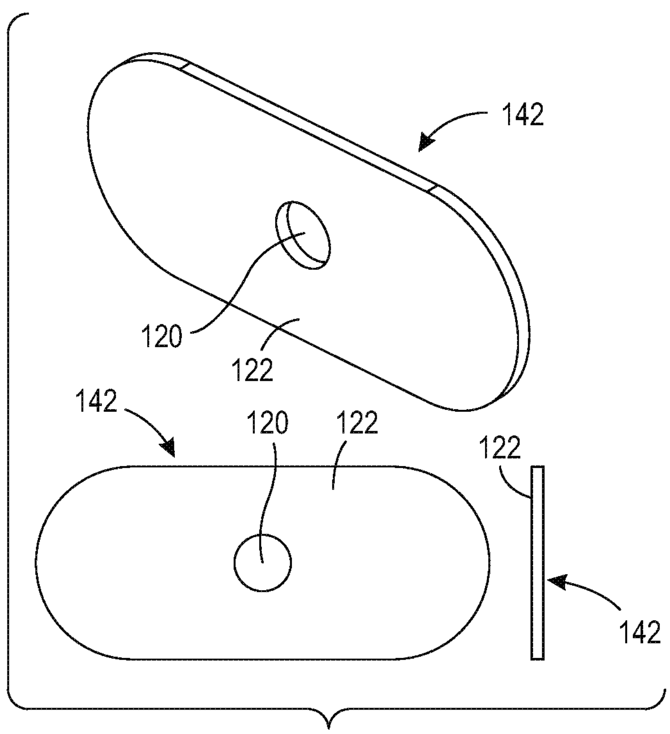
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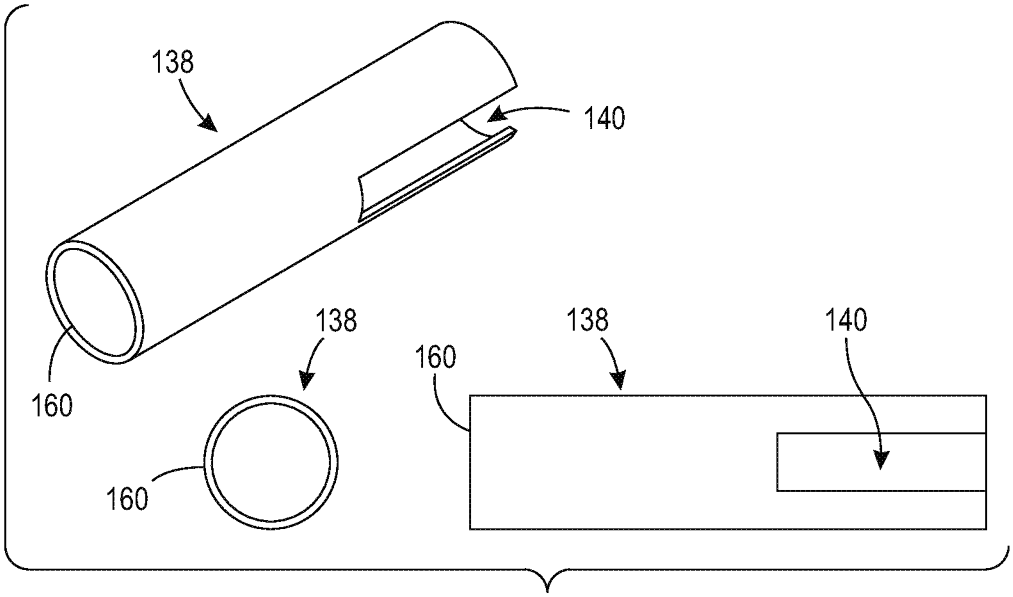
FIG. 5



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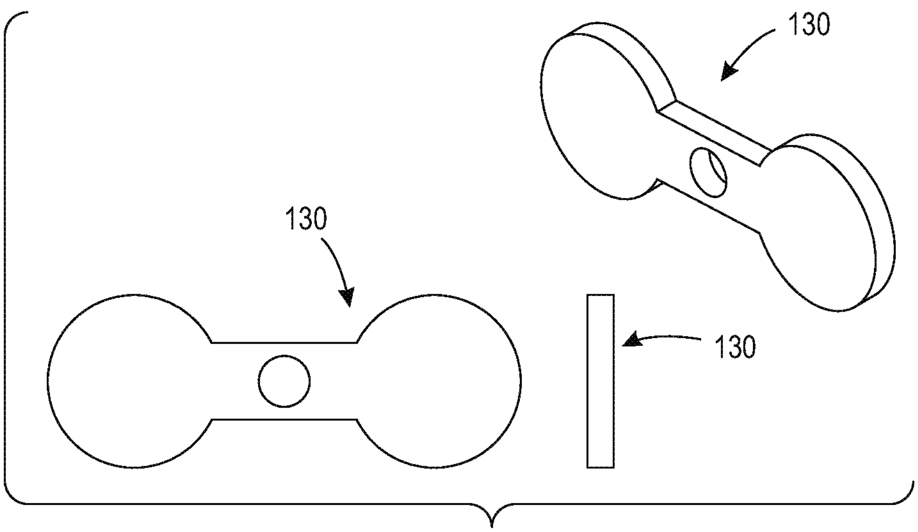

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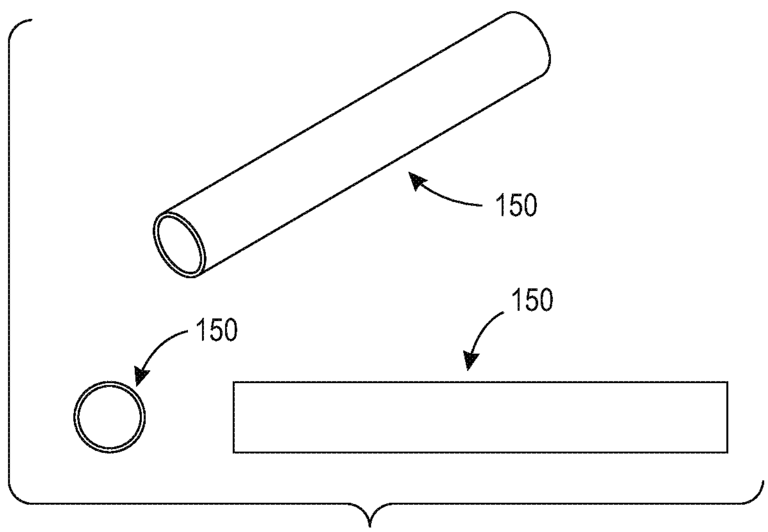

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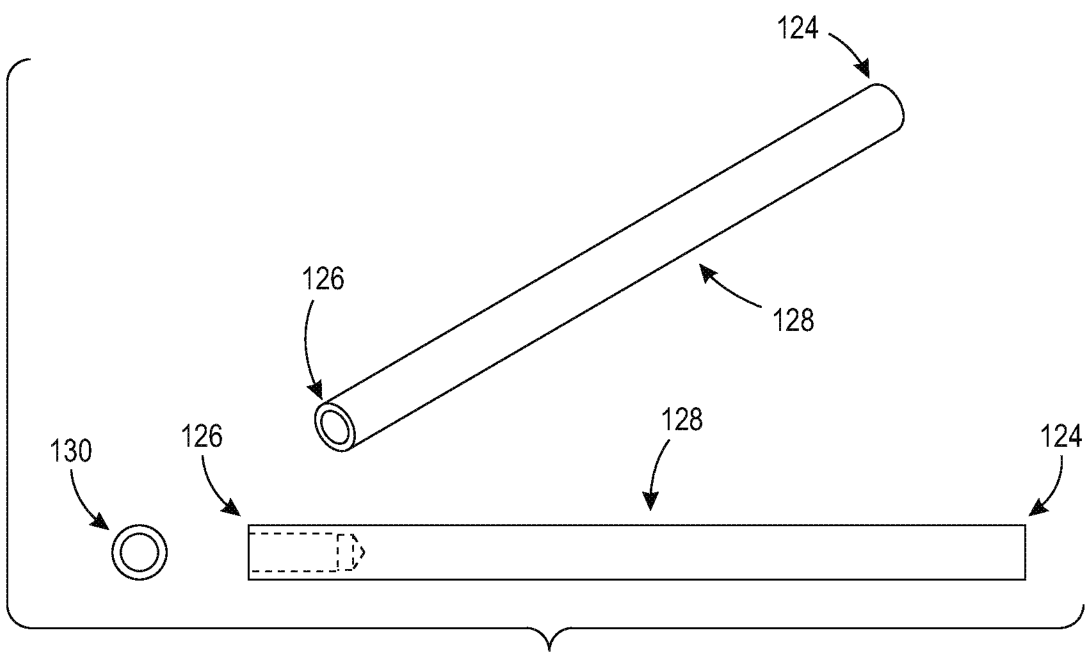

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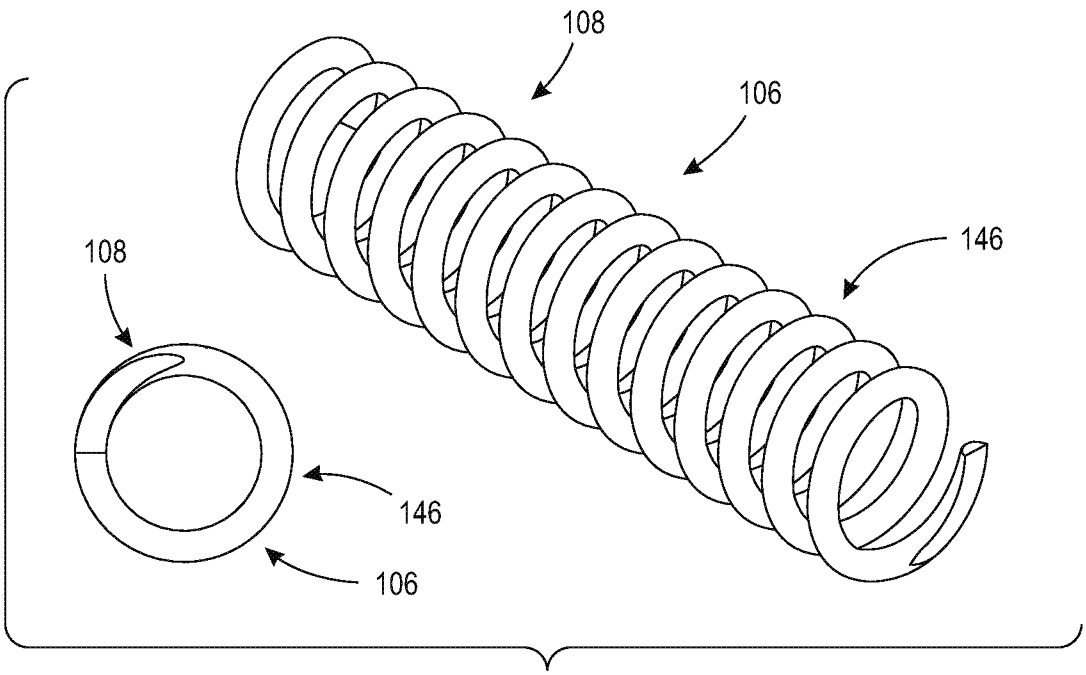

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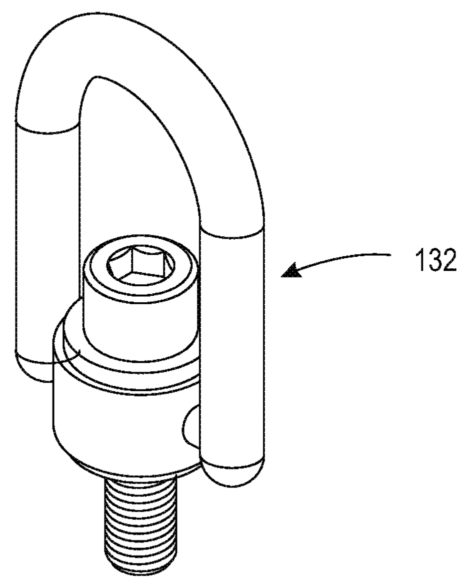

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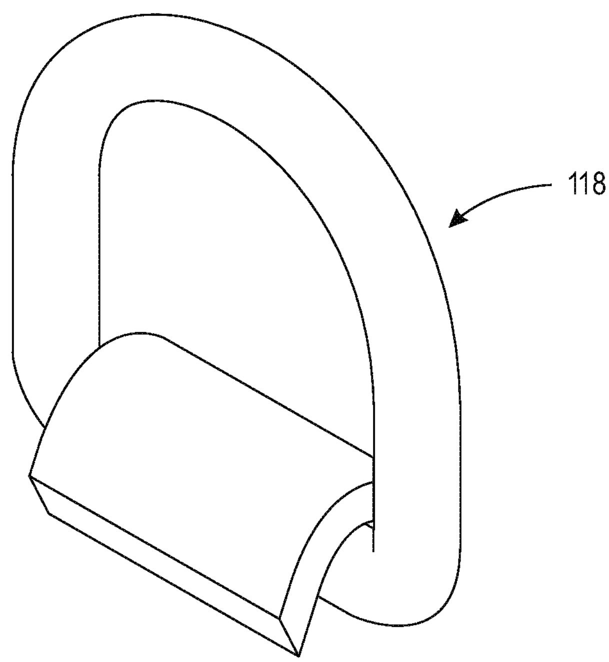

FIG. 12

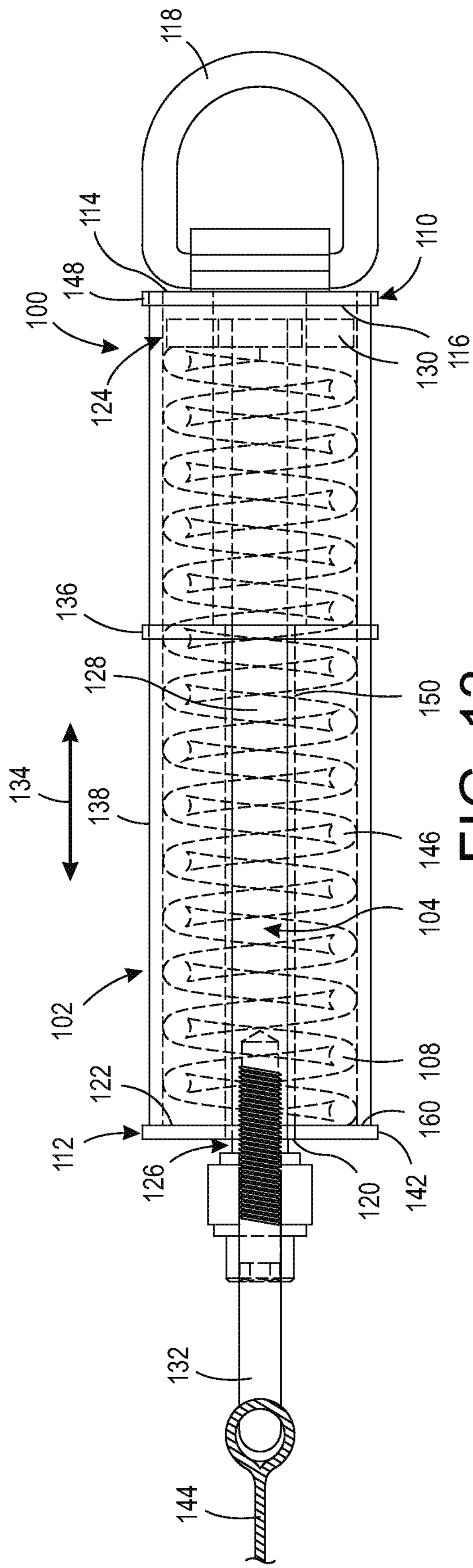
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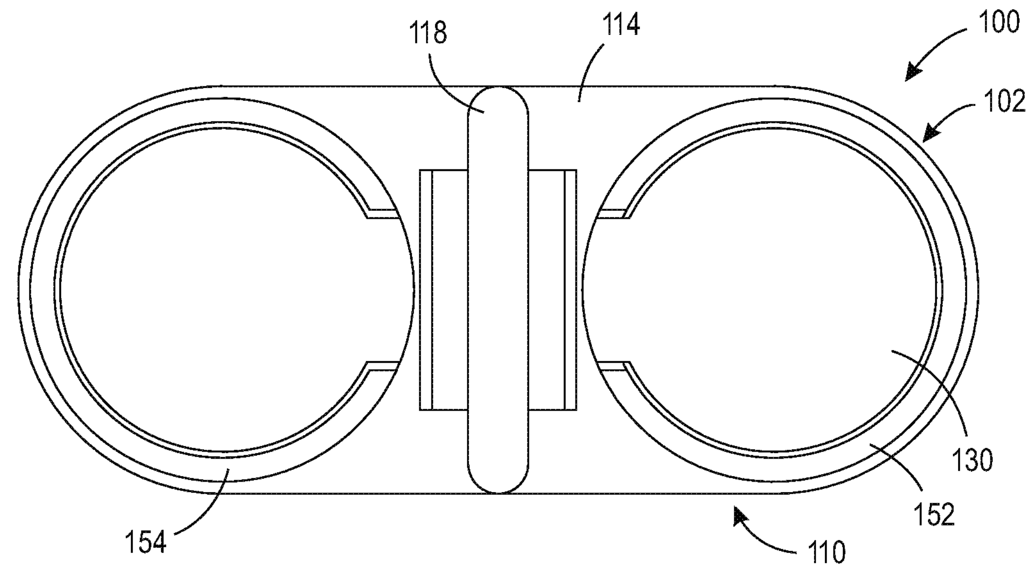
FIG. 13



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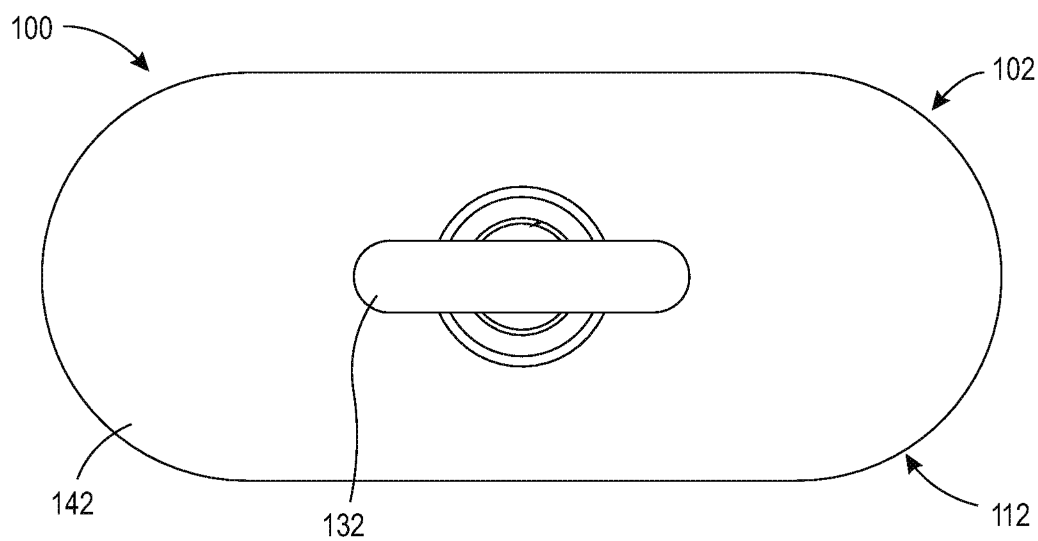

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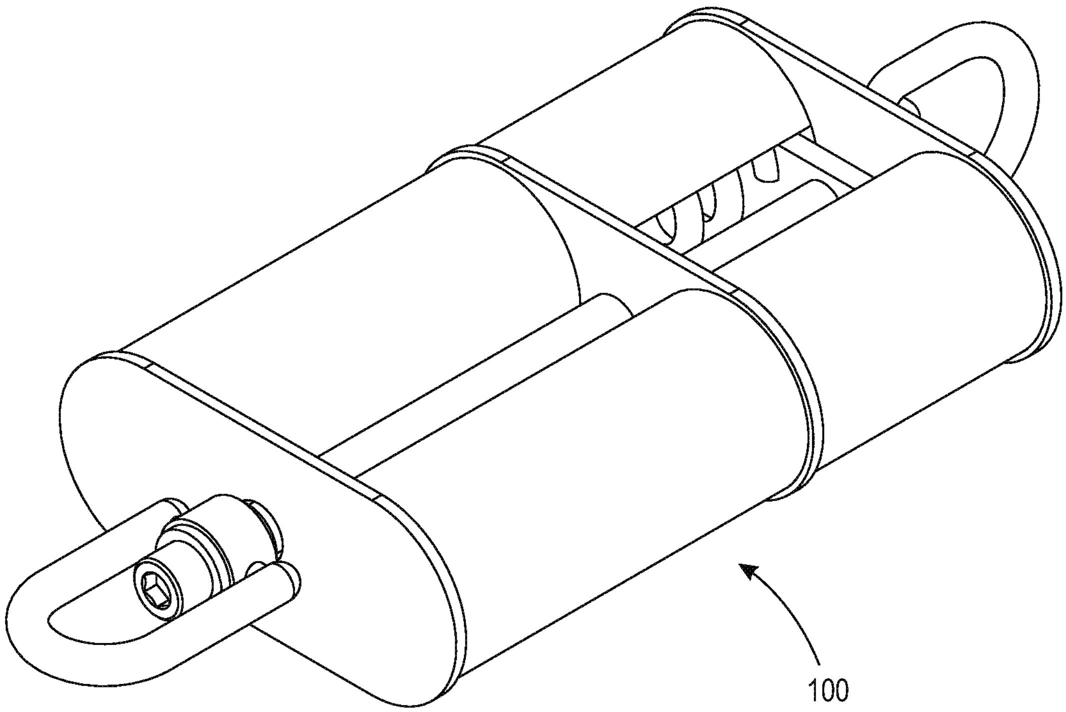

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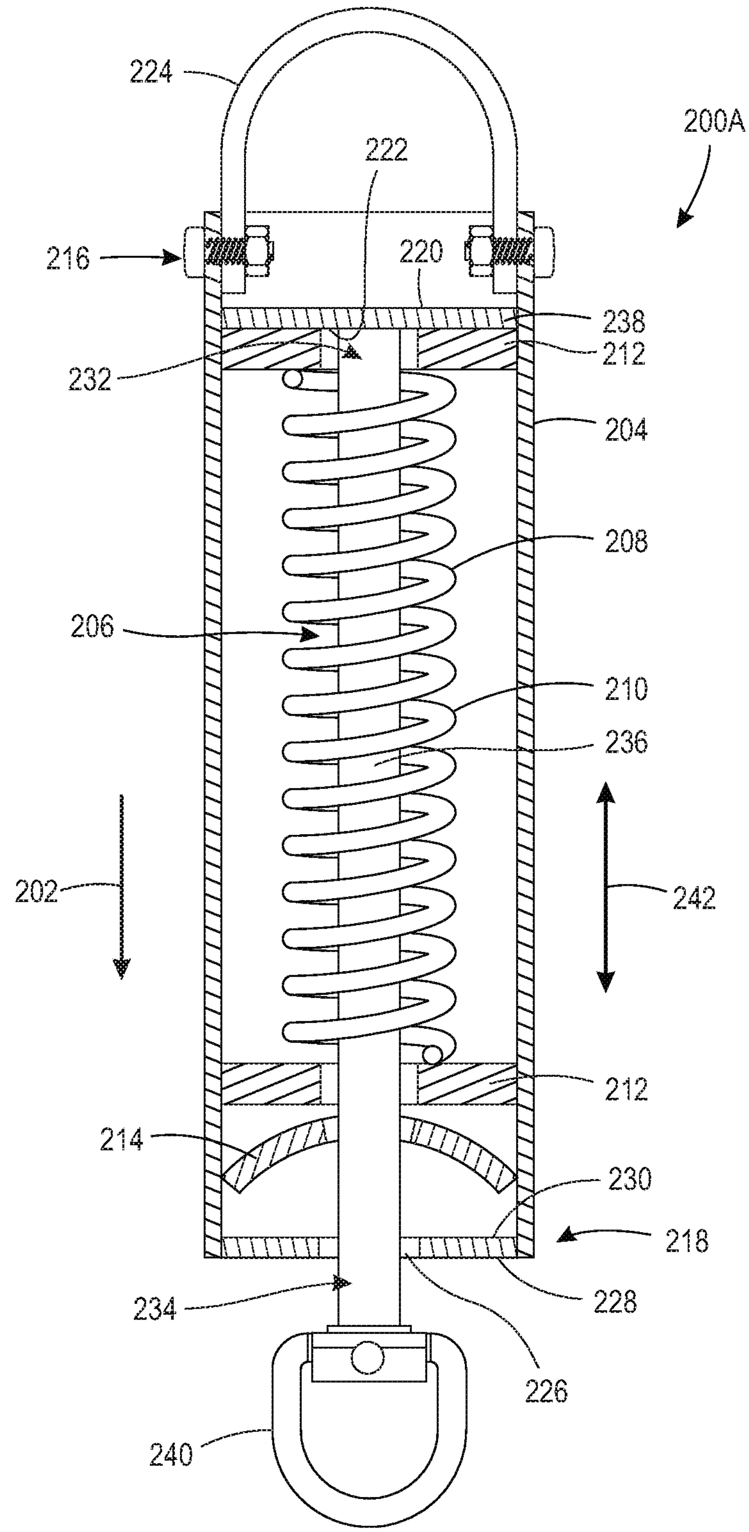
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FIG. 17

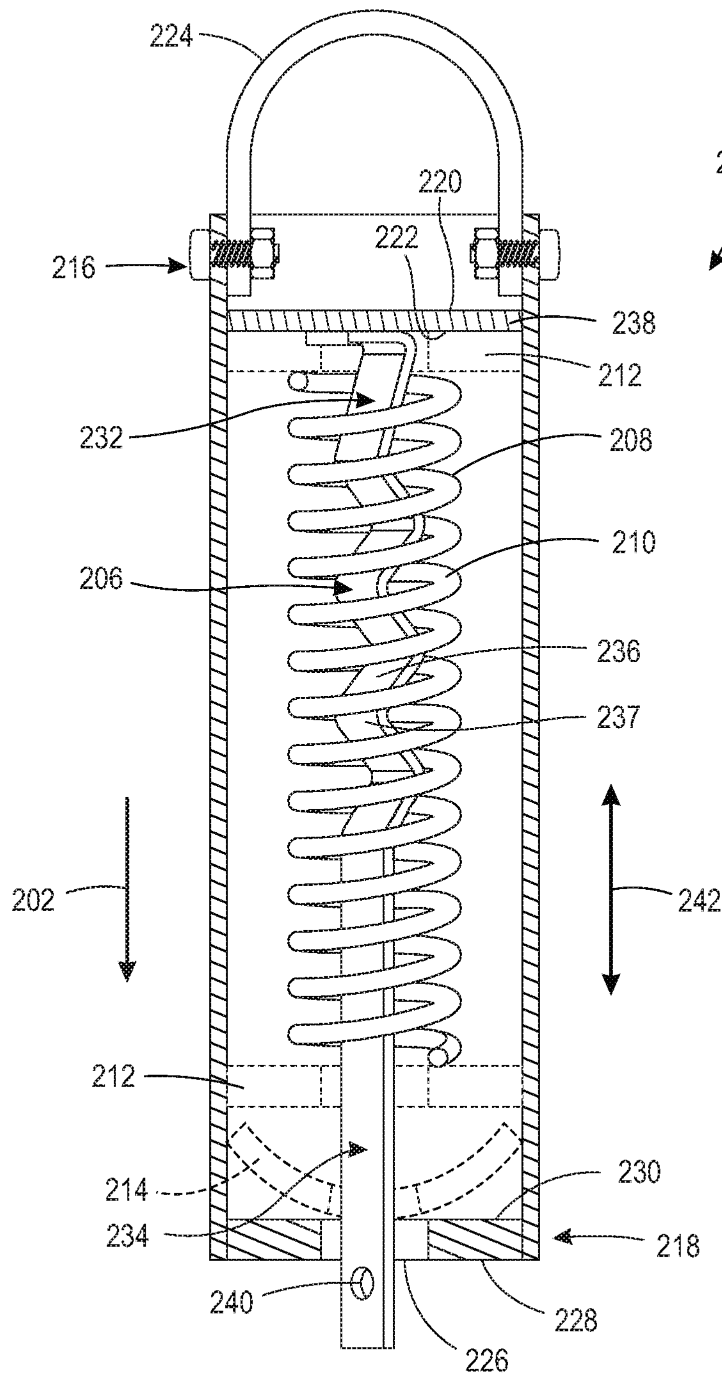
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FIG. 18A

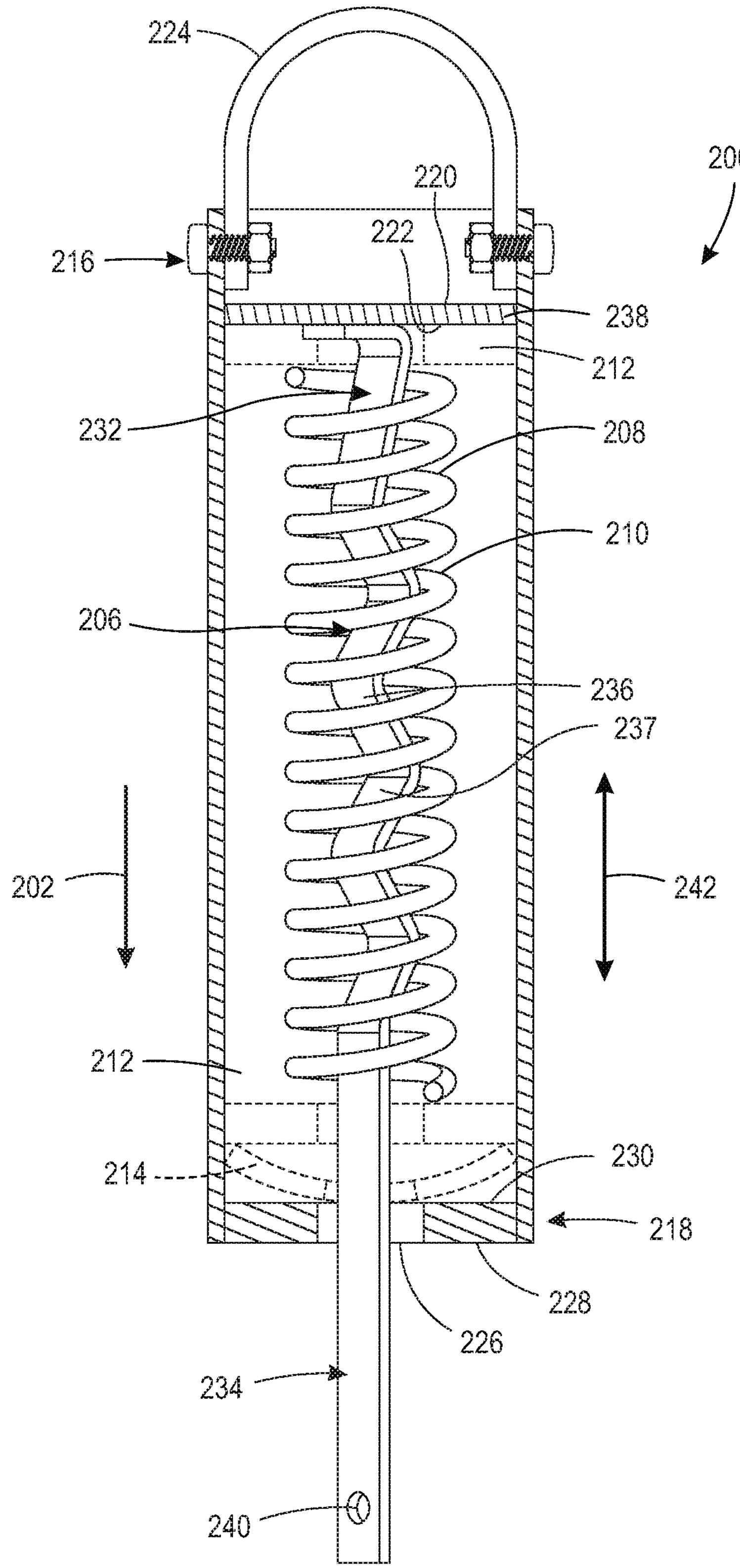
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FIG. 18B

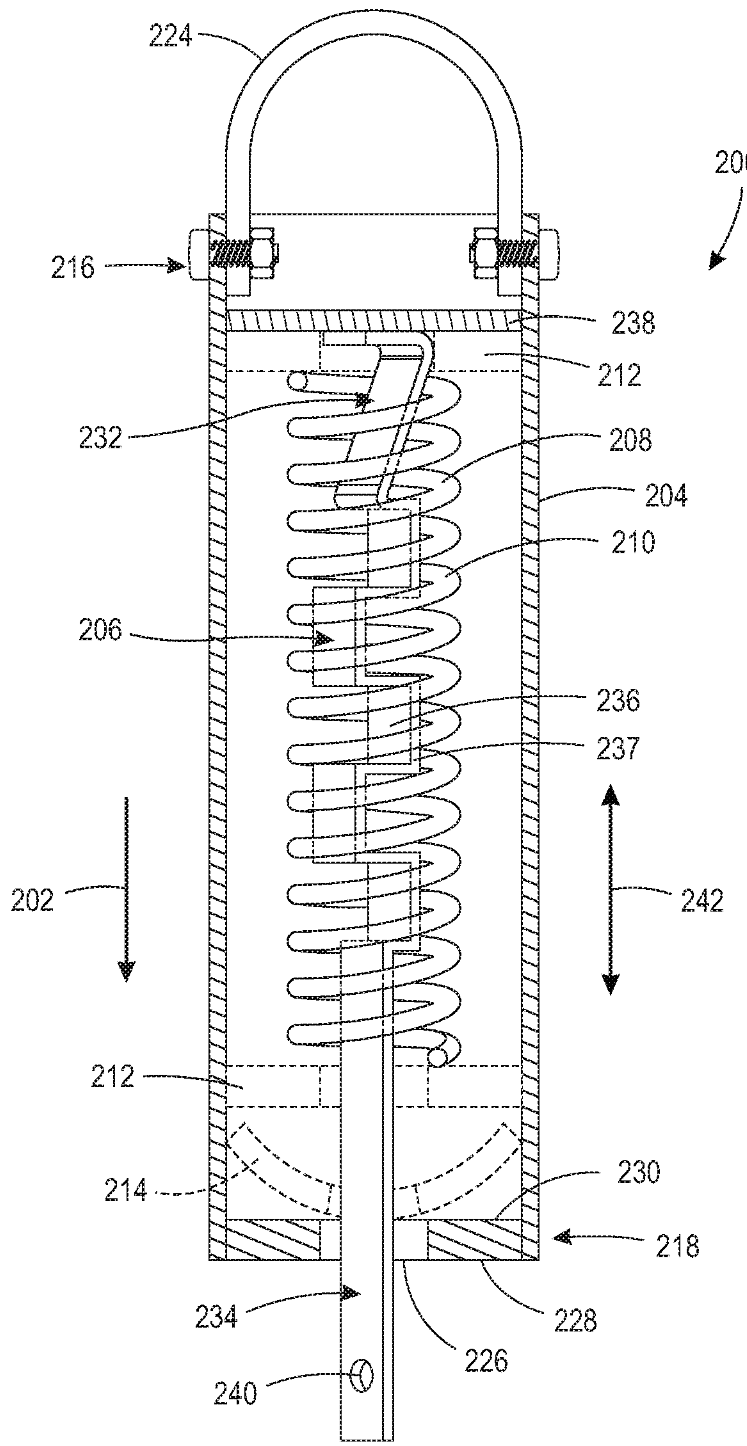
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FIG. 19

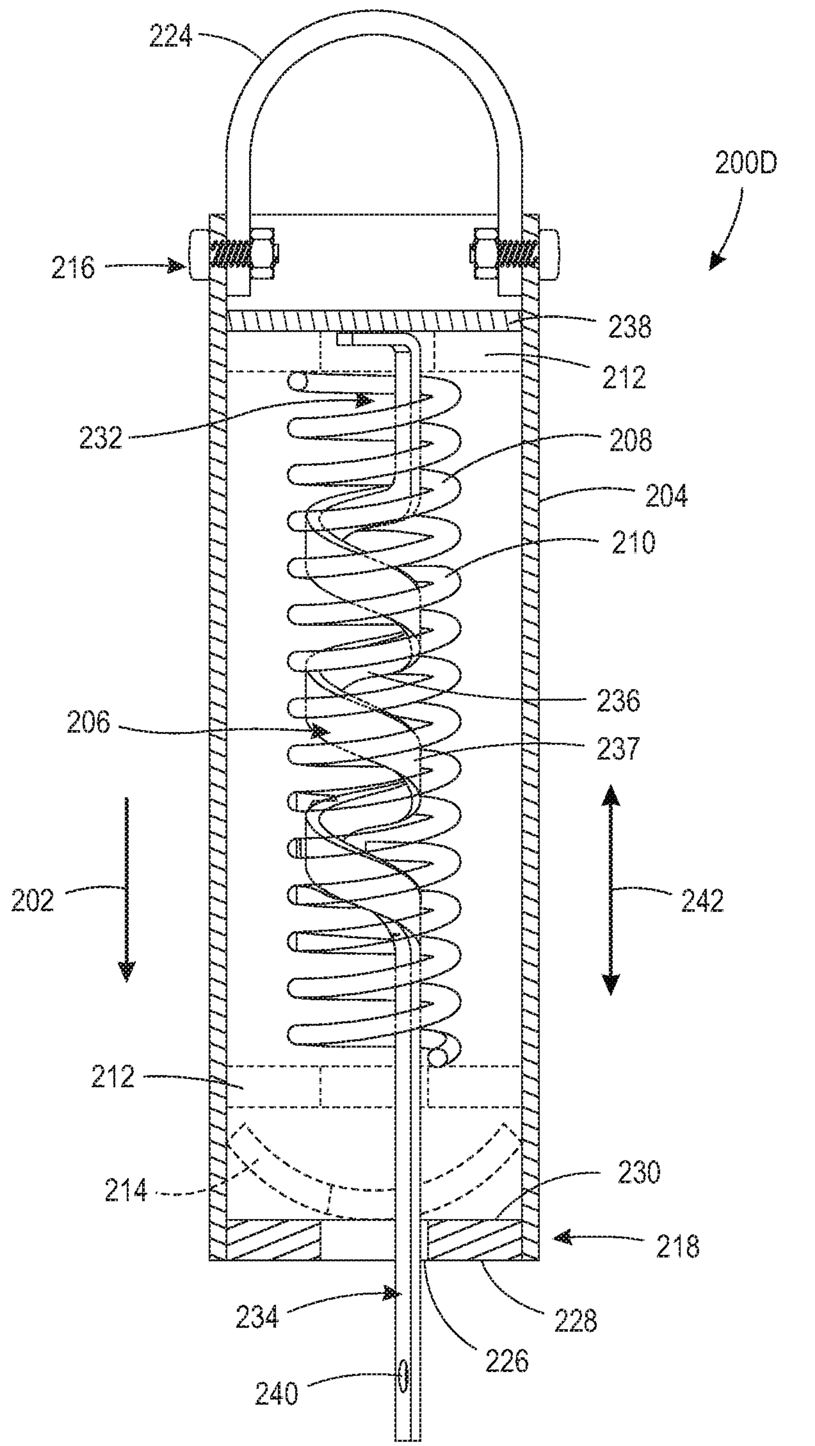
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FIG. 20

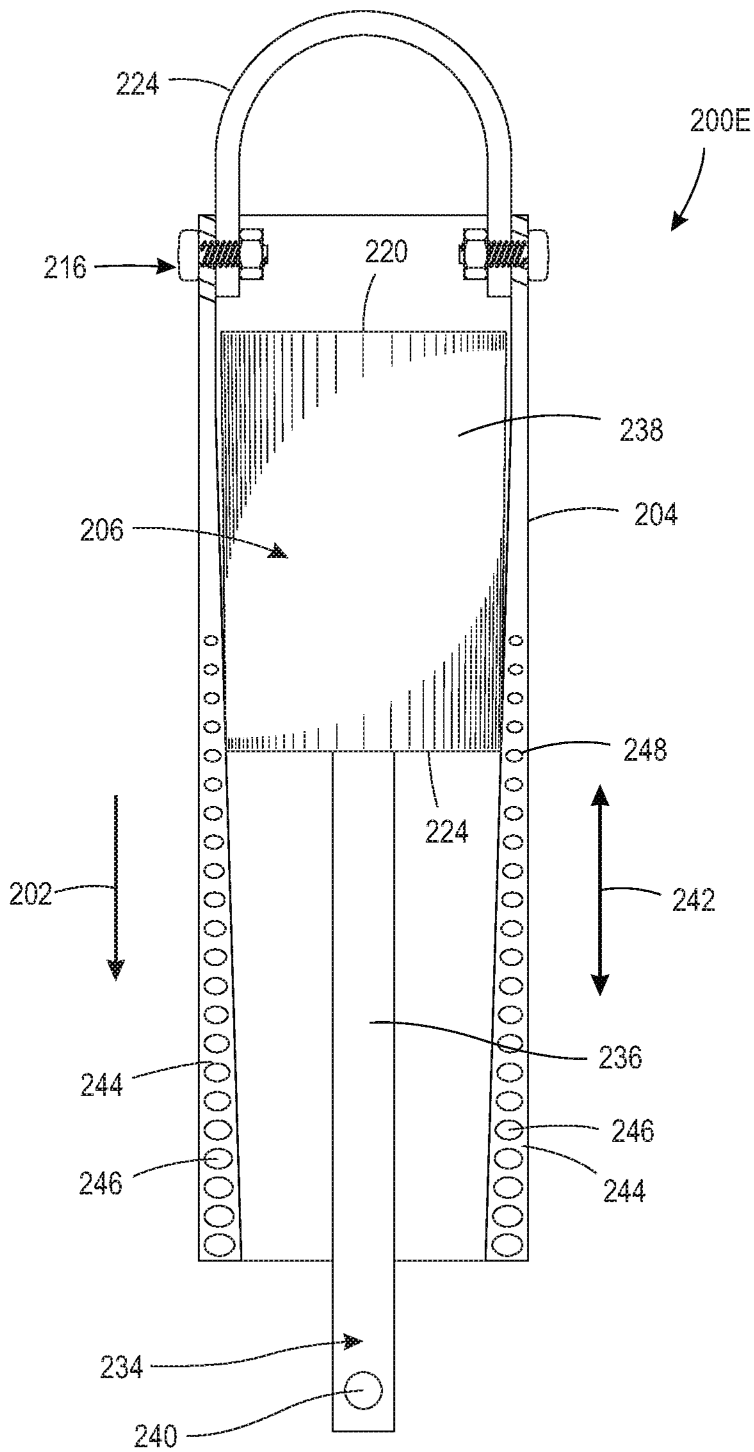
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FIG. 21A

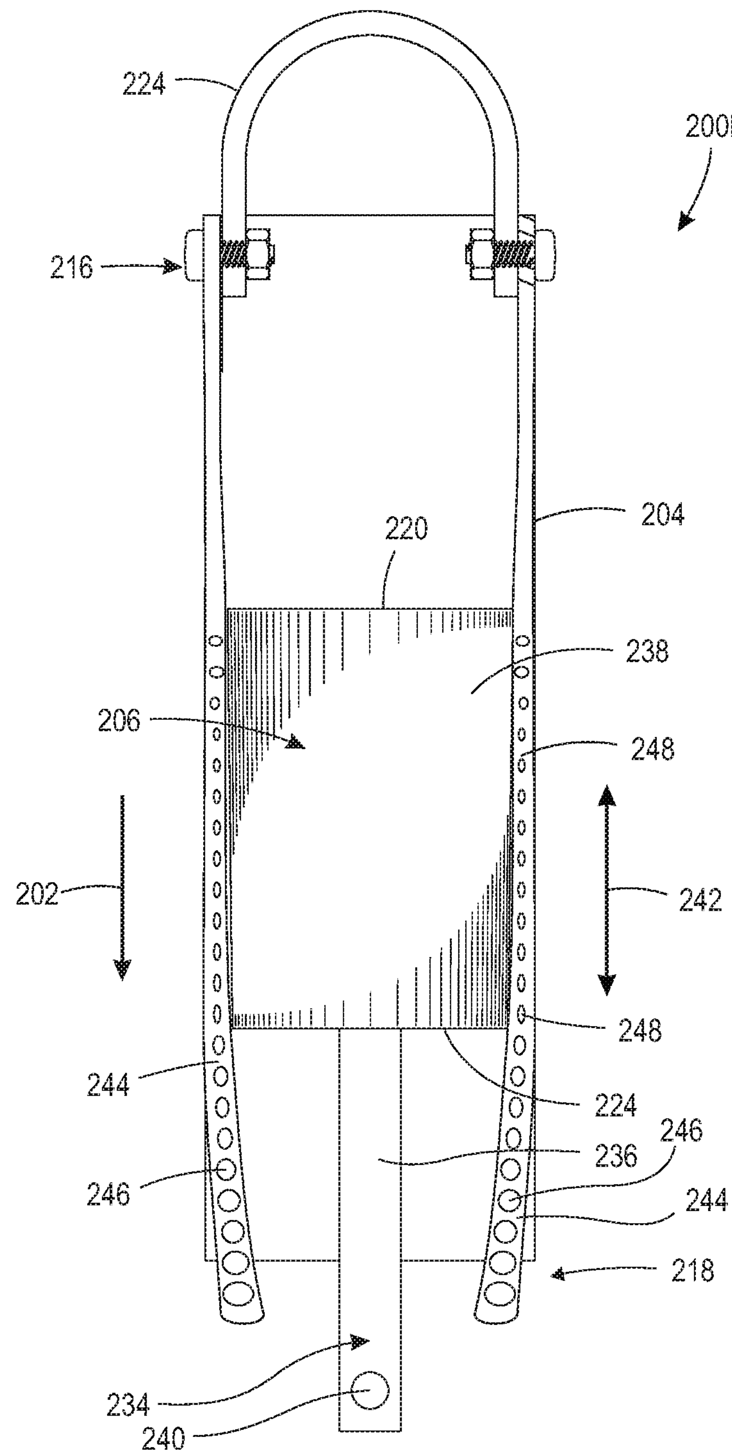
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FIG. 21B

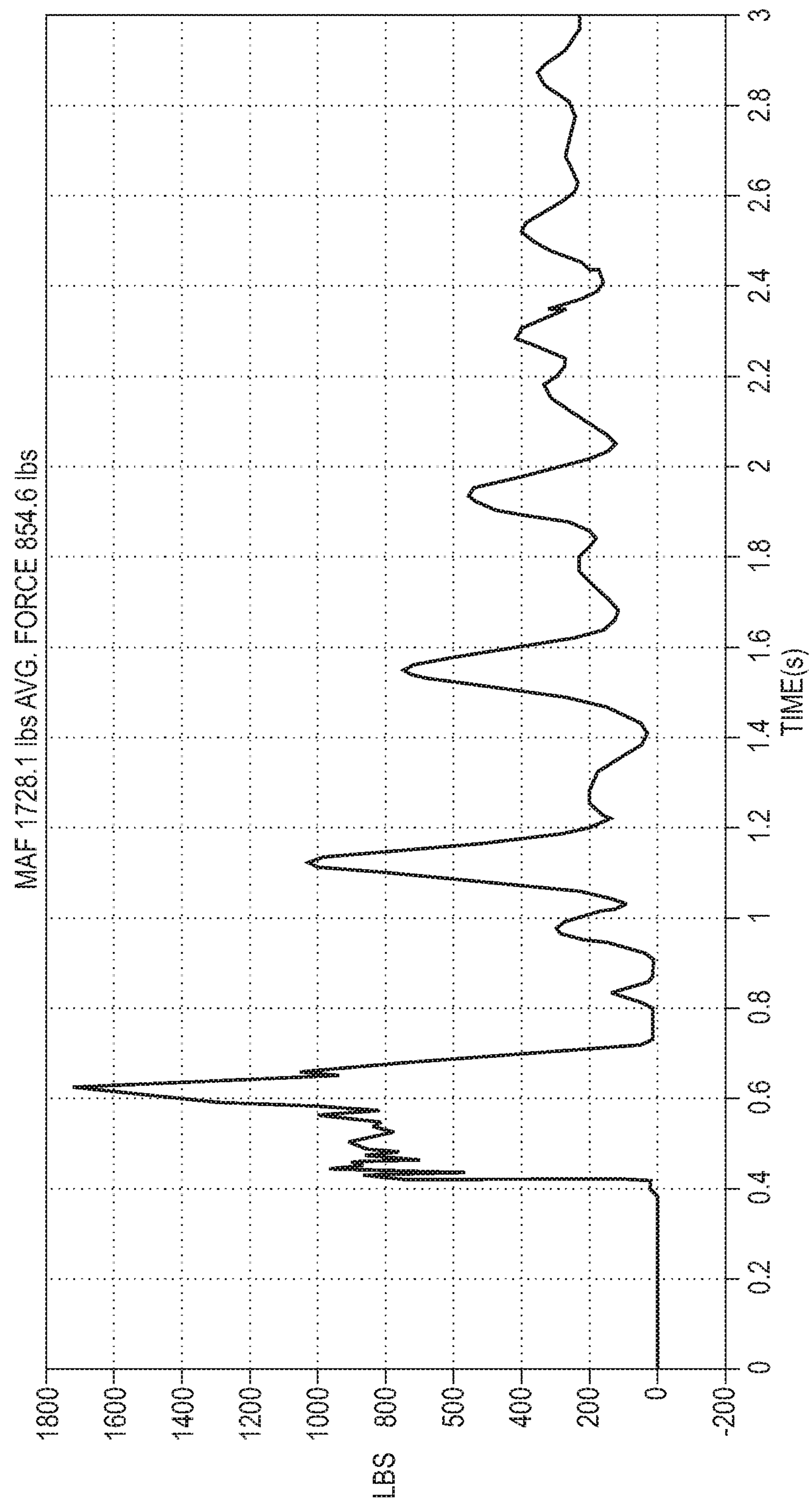
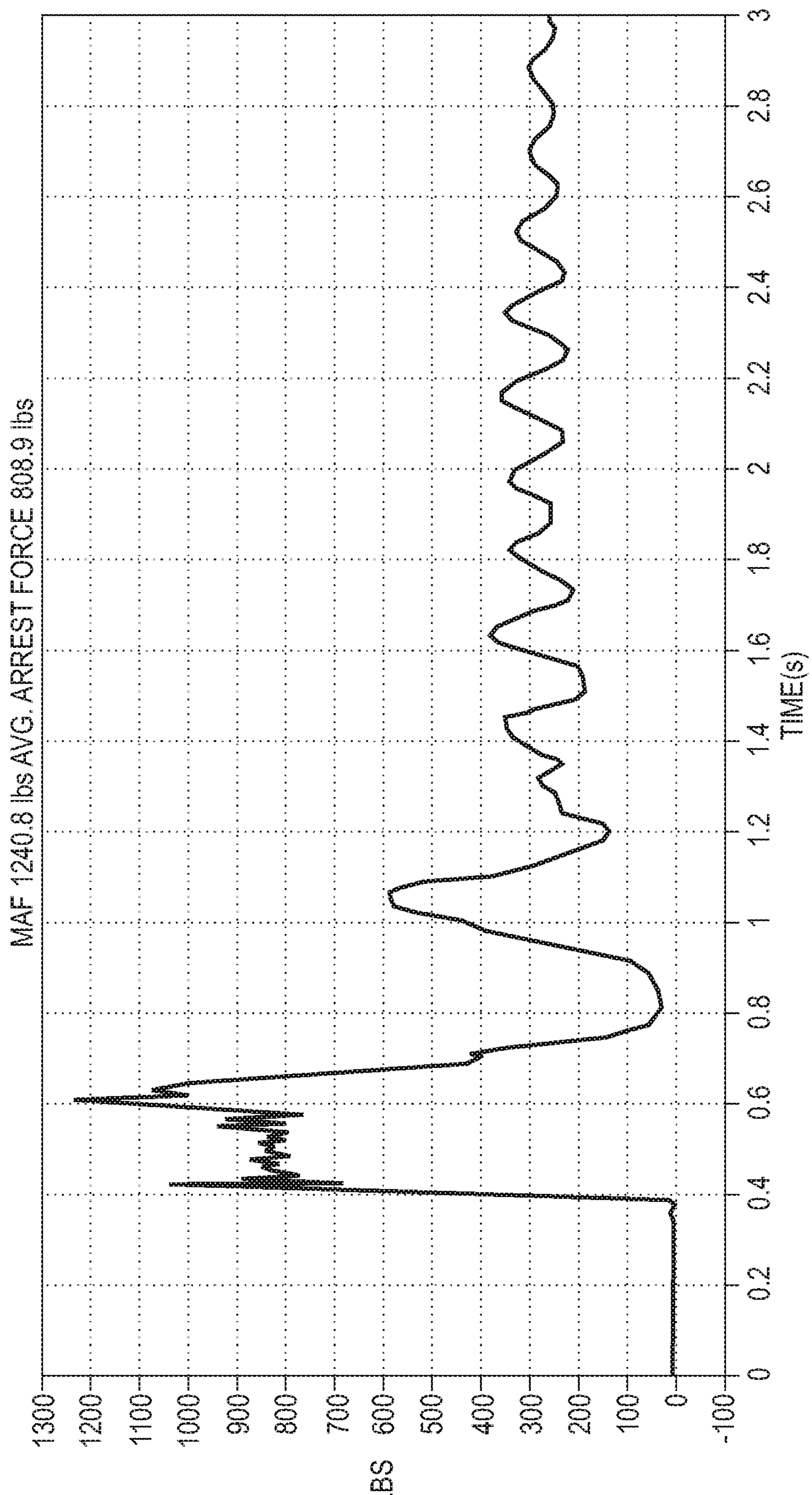

MAF 1728.1 lbs AVG. FORCE 854.6 lbs
LBS
1800
1600
1400
1200
1000
800
500
400
200
0
-200
TIME(s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3

FIG. 22


MAF 1240.8 lbs AVG. ARREST FORCE 808.9 lbs
LBS
TIME(s)
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1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
0
0.2
0.4
0.6
0.8
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1.4
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1.8
2
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2.4
2.6
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FIG. 23

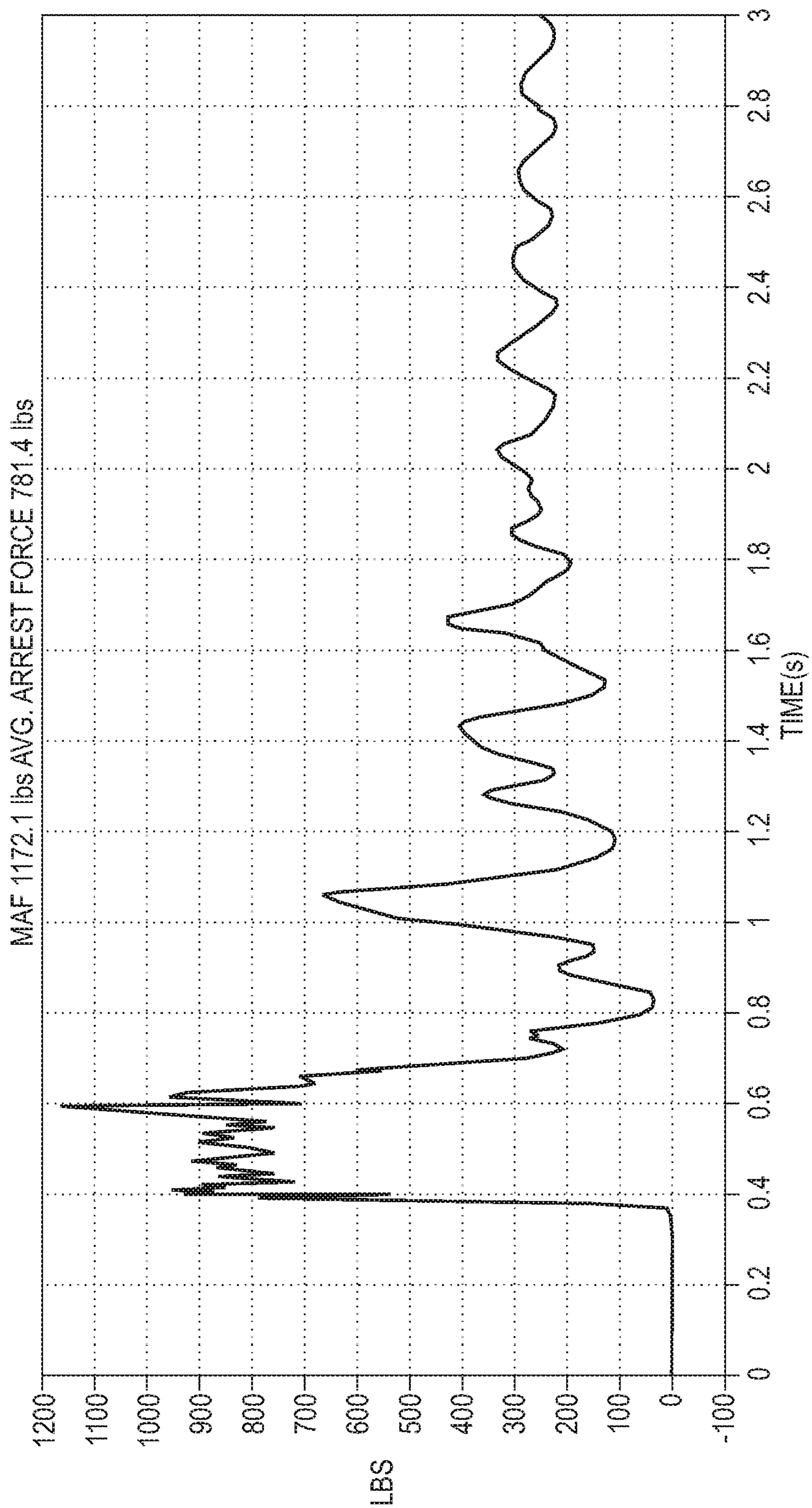
MAF 1172.1 lbs AVG. ARREST FORCE 781.4 lbs
LBS
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
-100
TIME(s)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3

FIG. 24

FORCE DAMPER

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of U.S. patent application Ser. No. 16/113,618, filed Aug. 27, 2018, which application claims the benefit under 35 U.S.C. § 119(e) of U.S. Provisional Patent Application No. 62/610,786, filed Dec. 27, 2017, which application is incorporated herein by reference.

FIELD

The invention broadly relates to a force damper, more specifically to a force damper used as a fall mitigation device, and even more particularly to a force damper used as a fall mitigation device having a single use, collapsible/compressible/compactable resilient member arranged to prevent reuse of the force damper after arresting a falling object, e.g., a roofing construction worker.

BACKGROUND

Fall prevention and fall arrest systems are known in the art. For example, one such system includes a stretchable shock absorbing lanyard, e.g., Model No. 1340101 PRO™ Stretch Shock Absorbing Lanyard manufactured by Protecta®. The inner core of the device extends from about four and a half feet to about six feet while absorbing energy of a falling object. Although this device may be suitable in some situations, it cannot ensure safety in situations where the falling height is similar to the height of the object falling, e.g., a worker that is six feet falling off an elevated level of seven feet. However, heretofore, such damper devices were arranged to be reused over and over again.

Regulations and/or a desire to ensure worker safety have created a need for force damping systems that cannot be used more than a single time as the integrity of a previously used force damper cannot be verified. For example, a force damper used to slow the fall of a three hundred pound object may not perform effectively while slowing the fall of a three hundred pound object a second time, while the same force damper may perform repeatably when slowing the fall of a one hundred fifty pound object. Thus, there is a long-felt need for a force damper that is easy to operate, inexpensive to build, safe for its intended use and that precludes subsequent uses.

SUMMARY

The present invention broadly comprises a force damper arranged to progressively arrest a first force imparted by an object moving in a first direction, the force damper including a housing, a driving member and a resilient member. The housing includes a first end and a second end, the first end having a first surface, a second surface opposite the first surface and a first connection point secured to the first surface, and the second end having a through bore and a third surface opposingly disposed relative to the second surface. The driving member includes a first end, a second end and a shaft therebetween, the first end comprises a stop and the second end comprises a second connection point. The resilient member is formed from a material that at least partially undergoes plastic deformation when the first force is arrested. The resilient member is disposed between the stop and the third surface and imparts a second force on the stop toward the second surface.

The present invention also broadly comprises a force damper arranged to progressively arrest a first force imparted by an object moving in a first direction, the force damper including a housing, a driving member and first and second resilient members. The housing includes a first end and a second end, the first end having a first surface, a second surface opposite the first surface and a first connection point secured to the first surface, and the second end having a through bore and a third surface opposingly disposed relative to the second surface. The driving member includes a first end, a second end and a shaft therebetween, the first end having a stop and the second end having a second connection point. At least one of the first and second resilient members is formed from a material that at least partially undergoes plastic deformation when the first force is arrested. The first and second resilient members are disposed between the stop and the third surface and impart a second force on the stop toward the second surface.

These and other objects and advantages of the present invention will be readily appreciable from the following description of preferred embodiments of the invention and from the accompanying drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The nature and mode of operation of the present invention will now be more fully described in the following detailed description of the invention taken with the accompanying drawing figures, in which:

FIG. **1** is a side cross sectional view of an embodiment of a present force damper;

FIG. **2** is a top perspective view of an embodiment of a present force damper;

FIG. **3** is a front perspective, a side elevational and a front elevational view of an embodiment of a plate included in some embodiments of a present force damper;

FIG. **4** is a front perspective, a side elevational and a front elevational view of an embodiment of a plate included in some embodiments of a present force damper;

FIG. **5** is a front perspective, a side elevational and a front elevational view of an embodiment of a plate included in some embodiments of a present force damper;

FIG. **6** is a front perspective, a side elevational and a front elevational view of an embodiment of a tube included in some embodiments of a present force damper;

FIG. **7** is a front perspective, a side elevational and a front elevational view of an embodiment of a stop included in some embodiments of a present force damper;

FIG. **8** is a front perspective, a side elevational and a front elevational view of an embodiment of a tube included in some embodiments of a present force damper;

FIG. **9** is a front perspective, a side elevational and a front elevational view of an embodiment of a shaft included in some embodiments of a present force damper;

FIG. **10** is a front perspective and a front elevational view of an embodiment of a resilient member included in some embodiments of a present force damper;

FIG. **11** is a front perspective view of an embodiment of a connection point included in some embodiments of a present force damper;

FIG. **12** is a front perspective view of an embodiment of a connection point included in some embodiments of a present force damper;

FIG. **13** is a side cross sectional view of an embodiment of a present force damper;

FIG. **14** is a front elevational view of an embodiment of a present force damper;

FIG. **15** is a back elevational view of an embodiment of a present force damper;

FIG. **16** is a top perspective view of an embodiment of a present force damper;

FIG. **17** is a side cross sectional view of an embodiment of a present force damper;

FIGS. **18**A and **18**B are side cross-sectional views of embodiments of a present force damper before (FIG. **18**A) and after (FIG. **18**B) application of a force upon a driving member shaft;

FIG. **19** is a side cross sectional view of an embodiment of a present force damper;

FIG. **20** is a side cross sectional view of an embodiment of a present force damper;

FIGS. **21**A and **21**B are side cross-sectional views of embodiments of a present force damper before (FIG. **21**A) and after (FIG. **21**B) application of a force upon a driving member shaft; and,

FIGS. **22-24** are graphical representations of results of drop tests of present embodiments of force dampers described herein.

DETAILED DESCRIPTION

At the outset, it should be appreciated that like drawing numbers on different drawing views identify identical, or functionally similar, structural elements of the invention. While the present invention is described with respect to what is presently considered to be the preferred aspects, it is to be understood that the invention as claimed is not limited to the disclosed aspects.

Furthermore, it is understood that this invention is not limited to the particular methodologies, materials and modifications described and as such may, of course, vary. It is also understood that the terminology used herein is for the purpose of describing particular aspects only, and is not intended to limit the scope of the present invention, which is limited only by the appended claims.

Unless defined otherwise, all technical and scientific terms used herein have the same meaning as commonly understood to one of ordinary skill in the art to which this invention belongs. Although any methods, devices or materials similar or equivalent to those described herein can be used in the practice or testing of the invention, the preferred methods, devices, and materials are now described.

It should be understood that use of “or” in the present application is with respect to a “non-exclusive” arrangement, unless stated otherwise. For example, when saying that “item x is A or B,” it is understood that this can mean one of the following: (1) item x is only one or the other of A and B; (2) item x is both A and B. Alternately stated, the word “or” is not used to define an “exclusive or” arrangement. For example, an “exclusive or” arrangement for the statement “item x is A or B” would require that x can be only one of A and B. Moreover, as used herein, the phrases “comprises at least one of” and “comprising at least one of” in combination with a system or element is intended to mean that the system or element includes one or more of the elements listed after the phrase. For example, a device comprising at least one of: a first element; a second element; and, a third element, is intended to be construed as any one of the following structural arrangements: a device comprising a first element; a device comprising a second element; a device comprising a third element; a device comprising a first element and a second element; a device comprising a first element and a third element; a device comprising a first element, a second element and a third element; or, a device comprising a second element and a third element. A similar interpretation is intended when the phrase “used in at least one of:” is used herein. Furthermore, as used herein, “and/or” is intended to mean a grammatical conjunction used to indicate that one or more of the elements or conditions recited may be included or occur. For example, a device comprising a first element, a second element and/or a third element, is intended to be construed as any one of the following structural arrangements: a device comprising a first element; a device comprising a second element; a device comprising a third element; a device comprising a first element and a second element; a device comprising a first element and a third element; a device comprising a first element, a second element and a third element; or, a device comprising a second element and a third element.

It should be appreciated that the term “substantially” is synonymous with terms such as “nearly,” “very nearly,” “about,” “approximately,” “around,” “bordering on,” “close to,” “essentially,” “in the neighborhood of” “in the vicinity of” etc., and such terms may be used interchangeably as appearing in the specification and claims. It should be appreciated that the term “proximate” is synonymous with terms such as “nearby,” “close,” “adjacent,” “neighboring,” “immediate,” “adjoining,” etc., and such terms may be used interchangeably as appearing in the specification and claims. The term “approximately” is intended to mean values within ten percent of the specified value.

By “non-rotatably connected” elements, we mean that: the elements are connected so that whenever one of the elements rotate, all the elements rotate; and relative rotation between the elements is not possible. Radial and/or axial movement of non-rotatably connected elements with respect to each other is possible, but not required. Additionally, “plastic deformation” is intended to mean instances when a sufficient load is applied to a material that causes a permanent change in shape to that material.

Adverting now to the figures, it should be appreciated that the figures depict various embodiments of the present force damper. The elevated work surface, e.g., roof, the falling object, e.g., a worker, a tool, a container filled with materials, etc., are not shown in the figures. One of ordinary skill in the art will readily appreciate the type, form and arrangement of each of the foregoing structures and therefore depiction in the figures is unnecessary. For the purpose of clarity in the detailed description, these structures are not included in the figures; however, the structures are discussed herebelow.

The present invention broadly includes force damper **50** arranged to progressively arrest a first force imparted by an object moving in a first direction, i.e., the direction depicted by arrow **51**. Force damper **50** comprises housing **52**, driving member **54** and resilient member **56**. Housing **52** comprises first end **58** and second end **60**. First end **58** includes first surface **62**, second surface **64** opposite first surface **62** and first connection point **66** secured to first surface **62**. Second end **60** includes through bore **68** and third surface **70** opposingly disposed relative to second surface **64**. Driving member **54** comprises first end **72**, a second end **74** and shaft **76** therebetween. First end **72** comprises stop **78** and second end **74** comprises second connection point **80**. Resilient member **56** is formed from a material that at least partially undergoes plastic deformation when the first force is arrested. Resilient member **56** is disposed between stop **78** and third surface **70**, and imparts a second force on stop **78** toward second surface **64** and on second end **60** toward third surface **70**, as depicted by bi-directional arrow **82**.

In some embodiments, housing **52** encloses resilient member **56**. In some embodiments, second end **60** of housing **52** comprises block **84**. Block **84** comprises through bore **68** and third surface **70**. In some of these embodiments, block **84** is formed from a urethane material. Thus, block **84** may provide force damping in addition to that of resilient member **56**. It should be appreciated that block **84** may also be formed from a rigid material, e.g., a metal, and in those embodiments block **84** does not provide additional force damping.

In some embodiments, resilient member **56** is a resilient polymer, a leaf spring, a shock absorber, and/or a compression spring, e.g., compression spring **86**. In some of these embodiments, resilient member **56** is compression spring **86**, and in some of these embodiments, compression spring **86** is formed from a chrome silicon steel material. In some embodiments, the compression springs described herein are between 4-12". In some embodiments, the compression springs described herein may be formed from elastomeric compounds such as elastomeric plastics, etc.

In some embodiments, force damper **50** further comprises securing line **88** selected from the group of: a rope, a cable, and/or a tether, and securing line **88** may in turn be connected to a harness and/or a belt. Subsequently, the object to be secured, e.g., a worker, a tool, a container, etc., is secured directly to the rope, cable and/or tether, or alternatively, secured directly to the harness and/or belt. It should be appreciated that securing line **88** is depicted as a rope only and that the structure and form of a cable and/or a tether are readily apparent to one having ordinary skill in the art and therefore depiction in the figures is unnecessary. Similarly, depiction of a subsequent harness and/or belt is also unnecessary. It should be further appreciated that various types of securing lines are more suitable for the present force damper, e.g., stretchable and/or shock absorbing ropes, as additional force may be damped by these types of securing lines. However, including such types of securing lines is not required.

In other embodiments, the present invention broadly includes force damper **100** arranged to progressively arrest a first force imparted by an object moving in a first direction, i.e., the direction depicted by arrow **101**. Force damper **100** comprises housing **102**, driving member **104** and first and second resilient members **106** and **108**, respectively. Housing **102** comprises first end **110** and second end **112**. First end **110** includes first surface **114**, second surface **116** opposite first surface **114** and first connection point **118** secured to first surface **114**. Second end **112** includes through bore **120** and third surface **122** opposingly disposed relative to second surface **116**. Driving member **104** comprises first end **124**, second end **126** and shaft **128** therebetween. First end **124** comprises stop **130** and second end **126** comprises second connection point **132**. At least one of first and second resilient members **106** and **108**, respectively, is formed from a material that at least partially undergoes plastic deformation when the first force is arrested. In other terms, one or both of first and second resilient members **106** and **108**, respectively, undergoes plastic deformation while arresting the first force. Thus, one of the resilient members may be arranged to arrest a portion of the force and display visible, permanent deformation while the other resilient member provides force damping while undergoing only elastic deformation, i.e., temporary shape change with restoration to its original shape after damping is complete. First and second resilient members **106** and **108**, respectively, are disposed between stop **130** and third surface **122**, and impart a second force on stop **130** toward second surface **116** and on second end **112** toward third surface **122**, as depicted by bi-directional arrow **134**.

In some embodiments, housing **102** further comprises reinforcement plate **136** arranged between first and second ends **110** and **112**, respectively, of housing **102**. In some embodiments, housing **102** at least partially encloses first and second resilient members **106** and **108**, respectively. It should be appreciated that "partially encloses" is depicted in the figures in that tubes **138** include open portions **140** which permit the linear actuation of stop **130** as force damper **100** arrests the first force imparted by the object moving in the first direction. In some embodiments, second end **112** of housing **102** comprises plate **142**. Plate **142** comprises through bore **120**. In some embodiments, force damper **100** further comprises securing line **144** selected from the group of: a rope, a cable, and/or a tether, and securing line **144** may in turn be connected to a harness and/or a belt. Subsequently, the object to be secured, e.g., a worker, a tool, a container, etc., is secured directly to the rope, cable and/or tether, or alternatively, secured directly to the harness and/or belt. It should be appreciated that securing line **144** is depicted as a rope only and that the structure and form of a cable and/or a tether are readily apparent to one having ordinary skill in the art and therefore depiction in the figures is unnecessary. Similarly, depiction of a subsequent harness and/or belt is also unnecessary. It should be further appreciated that various types of securing lines are more suitable for the present force damper, e.g., stretchable and/or shock absorbing ropes, as additional force may be damped by these types of securing lines. However, including such types of securing lines is not required.

In some embodiments, stop **130** extends perpendicularly from shaft **128** towards first and second resilient members **106** and **108**, respectively. As such, it should be appreciated that stop **130** is positioned between first and second resilient members **106** and **108**, respectively, and second surface **116**.

In some embodiments, first and second resilient members **106** and **108**, respectively, are formed from a resilient polymer, a leaf spring, a shock absorber, and/or a compression spring, e.g., compression spring **146**. In some of these embodiments, resilient members **106** and **108** are compression spring **146**, and in some of these embodiments, compression spring **146** is formed from a chrome silicon steel material. In some embodiments, the compression springs described herein are between 4-12". In some embodiments, the compression springs described herein may be formed from elastomeric compounds such as elastomeric plastics, etc.

Although the foregoing clearly sets forth the structure and function of various embodiments of the present force damper, a further description of the components of one of the embodiments may be helpful to further understand how the device functions. In various embodiments, force damper **100** may include a variety of additional components and such components are not required in all embodiments. However, it should be appreciated that it is possible to include all or some of the components described below in a single embodiment if desired.

In view of the foregoing, force damper **100** may include plate **148**, reinforcement plate **136**, plate **142**, tubes **138**, stop **130**, tube **150**, shaft **128**, resilient members **106** and **108**, and connection points **118** and **132**. When all of the foregoing components are included in force damper **100**, the following non-limiting arrangement is just one of the possibilities. Tubes **138** partially enclose resilient members **106** and **108**. Tubes **138** are passed through openings **152** and **154** in plate **148** and subsequently through openings **156** and **158** in reinforcement plate **136** until ends **160** of tubes **138** abut plate **142**. Connection point **118** is fixedly secured to plate **148**. Stop **130**, which is secured to end **124** of shaft **128**, is positioned within openings **140** of tubes **138** and between resilient members **106** and **108** and plate **148**. The foregoing arrangement permits the linear movement of stop **130** against resilient members **106** and **108** when force damper **100** is arresting a first force imparted by an object moving in a first direction. Reinforcement plate **136** may further include opening **162** wherein tube **150** is passed until it abuts plate **142**. Tube **150** provides an unrestricted passage for shaft **128** during its linear displacement. Moreover, the combination of reinforcement plate **136**, tube **150** and plate **142** strengthens the overall structure of force damper **100**. Plate **142** may include through bore **120** adjacent to the abutment of tube **150**. Through bore **120** provides access to second end **126** of shaft **128** and thereby a means to secure connection point **132** to shaft **128**. As can be appreciated in view of the foregoing, the pathway of force through the device is: connection point **118** to plate **148** to tubes **138** to plate **142** to resilient members **106** and **108** to stop **130** to shaft **128** to connection point **132**. It is this arrangement that permits the damping of force between connection points **118** and **132**, in this particular embodiment.

The foregoing arrangement results in a force damper that solves problems presented by regulatory agencies and worker safety concerns, i.e., a force damper in a fall mitigation system should only be used one time. The foregoing embodiments provide force damping over a reduced range of travel, e.g., the present force damper travels approximately three to six inches while absorbing the force of a falling object. Heretofore, existing force damping systems required far greater distance to damp the force of a falling object, e.g., two and a half to three feet. It should be appreciated that the present force damper system may be configured to travel lesser or greater lengths depending on the needs of the system. All the various resilient members described above may provide some elastic deformation, the resilient members are selected for particular falling masses that will always impart plastic deformation on at least one of the resilient members while they arrest a first force imparted by an object moving in a first direction. For example, one set of resilient members may be rated for arresting the force created by a falling object ranging from 100 kilograms (kg) to 150 kg, while a different set of resilient members may be rated for falling objects ranging from 150 kg to 200 kg. It is critical that at least one of the resilient members experiences plastic deformation so that single use of each the devices can be ensured. The plastic deformation of at least one of the resilient members with no return to its original shape/size provides a readily observable characteristic of the present force damper that ensures a user of the device can determine if it has been previously used for its intended purpose, i.e., arresting the force created by an object moving in a first direction.

Referring now to FIGS. **17-24**, further present embodiments of a force damper can include, for example, one or more resilient members used in association with a so-called Belleville washer having a frustoconical shape, driving member shafts including zig-zag-like, sinusoidal-like, or helical-like portions that may be elongated and plastically deformed upon application of a force to thereby attenuate the force applied thereto, or so-called compressible/collapsible/compactible crumple zones configured to be compressed/collapsed/compacted to thereby absorb/attenuate a force applied to the driving member shaft. It should be appreciated that while FIGS. **17-24** primarily illustrate embodiments of a force damper comprising a single housing and single driving member, etc., such embodiments comprise can more than a single housing and driving member shaft, and, for example, may comprise so-called dual-housing type embodiments.

As shown in FIG. **17**, for example, force damper **200**A is arranged to progressively arrest a first force imparted by an object moving in a first direction, i.e., the direction depicted by arrow **202**. Force damper **200**A comprises housing **204**, driving member **206** and resilient member **208**. Housing **204** comprises first end **216** and second end **218** and may be fabricated from materials such as steel, aluminum, other lightweight metals, fiberglass, carbon fiber, composites, or combinations thereof. First end **216** includes first surface **220**, second surface **222** opposite first surface **220** and first connection point **224** connected to housing **204**, for purposes of, for example, securing the force damper to a fixed structure or a fall arrest apparatus. Second end **218** includes through bore **226** and third surface **230** opposingly disposed relative to second surface **222**. Driving member **206** comprises first end **232**, a second end **234** and driving member shaft **236** therebetween. First end **232** comprises driving member stop **238** and second end **234** comprises second connection point **240** for purposes of, for example, securing an object or person thereto by means of a rope, cable, webbing, lanyard, tear-away lanyard, etc. (not shown). Resilient member **208** is formed from a material that at least partially undergoes plastic deformation when the first force is arrested. Resilient member **208** is disposed between driving member stop **238** and third surface **230** of housing end wall **228** and imparts a second force on driving member stop **238** toward second surface **222** and on second end **218** toward third surface **230**, as depicted by bi-directional arrow **242**.

In some embodiments, housing **204** encloses resilient member **208**. In some embodiments, one or more of first end **216** and second end **218** of housing **204** can comprise one or more semi-resilient members **212**. Semi-resilient members **212** comprise a through bore allowing driving member shaft **236** to pass therethrough. In some of these embodiments, semi-resilient members **212** are formed from a urethane material which serves to further attenuate a force applied to the driving member **206**. In some embodiments, semi-resilient member **212** is composed of 60 durometer urethane, or like compound, having a thickness between ⅜ and ½". Thus, semi-resilient members **212** may provide force damping in addition to that of resilient member **208**. In some embodiments, semi-resilient member **212**, e.g. a urethane washer, can be configured to be less compressible/extendable and/or resilient as compared to resilient member **208**, e.g., a spring member. As shown in FIG. **17**, a force damper may further include a so-called Belleville washer **214**, which is disposed within housing **204** between driving member stop **238** and end wall **228** of housing **204**. Belleville washer **214** has a frustoconical shape and includes a through bore allowing the driving member shaft **236** to pass therethrough. Belleville washer **214** can be formed from a plastically deformable material with no return to its original shape/size, such as a metal, plastics, polymers, from sacrificial/fracturable/frangible materials, or combinations thereof so as to provide a readily observable characteristic as to whether the force damper has been subject to prior use. Along this line, housing **204** may include a viewing window or slit proximate the location of Belleville washer **214** so to allow ready inspection thereof. It should be appreciated that while FIG. **17** illustrates Belleville washer **214** as being disposed between semi-resilient member **212** and end wall **228** of second end **218** of housing **204**, it may be positioned otherwise within housing **204** and at any position between end wall **228** and driving member stop **238**. In some cases, Belleville washer **214** can be formed of an elastically deformable material that returns to its original shape. Additionally, while FIG. **17** illustrates Belleville washer **214** being positioned such that its concave side is disposed toward end wall **218**, it may be positioned such that its concave side is oppositely positioned toward driving member stop **238**. Also, while only a single Belleville washer **214** is shown in FIG. **17**, more than one Belleville washer **214** may be utilized depending upon the specific application, i.e., the object and/or the amount of force to be attenuated/arrested. Where more than one Belleville washer **214** is utilized, they may be positioned to contact one another in a stacked, or nested-type arrangement, positioned such that they contact one another but do not nest with one another, positioned in such a way that that they do not contact one another, e.g. on opposite ends of housing **204**, or combinations thereof depending upon the specific application.

In some embodiments, resilient member **208** is a resilient polymer, a leaf spring, a shock absorber, and/or a compression spring, e.g., compression spring **210**. In some of these embodiments, resilient member **208** is compression spring **210**, and in some of these embodiments, compression spring **210** is formed from a chrome silicon steel material. In some embodiments, the compression springs described herein are between 4-12". In some embodiments, the compression springs described herein may be formed from elastomeric compounds such as elastomeric plastics, etc.

In some embodiments, force damper **220**A further comprises a securing line (not shown) selected from the group of: rope, cable, webbing, tether, lanyard, tear-away lanyard, combinations thereof, etc., and the securing line may in turn be connected to a harness and/or a belt. Subsequently, the object to be secured, e.g., a worker, a tool, a container, etc., is secured directly to the securing line rope, cable and/or tether, or alternatively, secured directly to the harness and/or belt. It should be further appreciated that various types of securing lines may be more suitable for the present force damper, e.g., stretchable and/or shock absorbing ropes, tear away lanyards, as additional force may be damped by these types of securing lines. However, including such types of securing lines is not required.

As shown in FIGS. **18**A-**20**, force dampers **200**B-**200**D are substantially similar to force damper **220**A, but are primarily different in that they can include differently configured driving member shafts **236**, which are configured to be elongated upon application of a sufficient force in the first direction **202**. That is, as force dampers **200**A-**200**D include similar structural elements, discussion of such similar structural elements is not re-presented herein, and the following description is substantially limited to a discussion of the differences between embodiments **200**A-**200**D.

As shown in FIGS. **18**A-**20** force dampers **200**B-**200**D are generally configured to comprise plastically deformable and elongatable driving member shafts **236** including zig-zag/sinusoidal/helical-like portions **237** positioned between driving member first end **232** and driving member second end **234**. As may be appreciated, in such embodiments, the driving member shaft **236** can be formed from a plastically deformable material that does not allow return to its original shape/size, such as a metal or certain polymers, from other sacrificial/non-reusable materials, or combinations thereof so as to provide a readily observable characteristic as to whether the force damper has been subject to prior use. As may be further appreciated, housing **204** may include a viewing window or slit proximate location of zig-zag/sinusoidal/helical-like portions **237** so to allow ready inspection thereof (not shown) such that operational state may be readily determined. In some aspects, however, driving member shafts **236** may be elastically deformable such that they substantially return to their original shapes.

As also shown in FIGS. **18**A-**20**, in the case of plastically deformable driving member shafts, the driving member shafts **236** including zig-zag/sinusoidal/helical-like portions **237** can be formed from a generally flat stock and include zig-zag-like folded/pleated portions **237** in the case of FIGS. **18**A and **18**B, square sinusoidal-type portions **237** in the case of FIG. **19**, and helical-type portions **237** in the case of FIG. **20**. As may be appreciated from FIGS. **18**A and **18**B, for example, prior to a force being applied to driving member shaft **236** including zig-zag-like folded/pleated portions **237** in first direction **202**, zig-zag-like folded/pleated portions **237** are maintained in a so-called start position. However, as shown in FIG. **18**B, upon application of a sufficient force, zig-zag-like folded/pleated portions **237** become elongated and are plastically deformed at the ending position shown by way of example in FIG. **18**B. Such elongation and plastic deformation serves to both further attenuate/dampen the force applied in the first direction, that may result from a falling object or person, and in the case of plastic deformation, also serves as an indicator that the force damper has been previously utilized. While not shown in any of FIGS. **18**A-**20**, driving member shafts **236** including zig-zag-like folded/pleated portions **237** can also be configured to include, for example, markings, colored markings, knurling, etching, etc. along a length thereof, for example, proximate through bore **226** of housing, to show whether the force damper has been previously utilized and the driving member shafts **236** elongated and subject to plastic deformation. For example, where the force damper has not been utilized, a colored marking proximate through bore **226** could be green in color to show that the force damper remains available for use, or red to indicate that it has been previously used and should be discarded. Additionally, it should be further appreciated that driving member shafts **236** including zig-zag/sinusoidal/helical-like portions **237** can be formed of stock of varying thickness and/or varying number of folds/pleats/turns based on the particular application and/or object that is secured thereto. In some embodiments, the driving member shafts **236** are formed from ⅛" steel. Furthermore, as shown in FIGS. **18**A-**20**, force dampers including driving member shafts **236** including zig-zag/sinusoidal/helical-like portions **237** can also optionally include semi-resilient members **212** and/or Belleville washers **214** (as shown by the dashed lines in such figures).

Turning now to FIGS. **21**A and **21**B, force damper **200**E, and other embodiments of force dampers described herein, may be configured to comprise a so-called collapsible/compressible/compactable crush zone configured to reduce or attenuate the amount of force applied in first direction **202**. As shown by way of example in FIGS. **21**A and **21**B, force damper **200**E can be configured to include driving member **206** having a driving member stop **238** having a tapered shape for purposes of contacting a collapsible/compressible/compactable tapered wall **244** of housing **204**. As shown in such figures, collapsible/compressible/compactable tapered wall **244** can include, for example, channels or interstitial portions **248** disposed between structural portions **244** thereof such that upon action by the tapered driving member stop **238**, such walls may collapse/compress/compact upon themselves and/or may be partially directionally disposed toward second end **218** as shown in FIG. **21**B. As may be appreciated, such so-called collapsible/compressible/compactable crush zones may be configured to comprise a structural member of the housing, e.g., a wall of the housing itself, or may be configured to comprise a member or zone secured, disposed on, or adhered to an inner wall of housing **204**. As may be further appreciated, collapsible/compressible/compactable zone **244** may be formed of metals, polymers, foams, resilient materials, fracturable or frangible materials, or combinations thereof. Additionally, while FIGS. **21**A and **21**B illustrate a force damper as comprising a so-called collapsible/compressible/compactable crush zone only, such zones may be used in association with one or more of the force damper embodiments or aspects thereof previously discussed herein. Walls of the housing and/or tapered wall **244** may also be configured in a stepped fashion, for example, to ensure that a collapsible/compressible/compactable member or zone secured, disposed on, or adhered to an inner wall of housing **204** is not dislodged as a result of the application of a force in the first direction.

Referring now to FIGS. **22**-**24**, which are graphical illustrations of drop tests performed according ANSI Z359 requirements in order to assess the dampening or attenuation of force provided by force dampers in accordance with the instant disclosure. In each of the drop tests of FIGS. **22**-**24**, a 282 pound weight was utilized, the weight dropped from a same height free and clear of obstructions, and each force damper included a driving member shaft including a zig-zag-like folded portion as shown, for example, in FIGS. **18**A and **18**B. In some tests, one or more of a Belleville washer and/or one or more urethane semi-resilient members were utilized. As shown in FIG. **22**, a dual housing/double spring force damper utilizing a 10" tear away/ripstop-type lanyard exhibited a Maximum Arresting Force (MAF)=1728.1 pounds and an Average Arresting Force (AAF)=854.6 pounds. As shown in FIG. **23**, a single housing/single spring force damper utilizing a 10" tear away/ripstop-type lanyard exhibited a Maximum Arresting Force (MAF)=1240.8 pounds and an Average Arresting Force (AAF)=808.9 pounds. Finally, as shown in FIG. **24**, a dual housing/double spring force damper utilizing a 12" tear away/ripstop-type lanyard exhibited a Maximum Arresting Force (MAF) =1172.1 pounds and an Average Arresting Force (AAF) =781.4 pounds. The aforementioned tests indicate that a force damper in accordance with instant disclosure comprises an improvement over currently known force dampers.

Thus, it is seen that the objects of the present invention are efficiently obtained, although modifications and changes to the invention should be readily apparent to those having ordinary skill in the art, which modifications are intended to be within the spirit and scope of the invention as claimed. It also is understood that the foregoing description is illustrative of the present invention and should not be considered as limiting. Therefore, other embodiments of the present invention are possible without departing from the spirit and scope of the present invention.

PARTS LIST

50 Force Damper
51 1st Direction/Force
52 Housing
54 Driving Member
56 Resilient Member
58 1st End
60 2nd End
62 1st Surface
64 2nd Surface
66 1st Connection Point
68 Through bore
70 3rd Surface
72 Driving Member 1st End
74 Driving Member 2nd End
76 Driving Member Shaft
78 Driving Member Stop
80 2nd Connection Point
82 2nd Direction/Force
84 Block
86 Compression Spring
88 Securing Line
100 Force Damper
101 Direction/Force
102 Housing
104 Driving Member
106 1st Resilient Member
108 2nd Resilient Member
110 Housing 1st End
112 Housing 2nd End
114 1st Surface
116 2nd Surface
118 1st Connection Point
120 Through bore
122 3rd Surface
124 Driving Member 1st End
126 Driving Member 2nd End
128 Driving Member Shaft
130 Driving Member Stop
132 2nd Connection Point
134 2nd Direction/Force
136 Reinforcement Plate
138 Tube(s)
140 Tube Open Portion
142 2nd End Plate
144 Securing Line
146 Compression Spring
148 1st End Plate
150 Tube
152 Opening
154 Opening
156 Opening
158 Opening
160 Tube **138** End
162 Opening
200A-**200**E Force Damper
202 1st Direction/Force
204 Housing
206 Driving Member
208 Resilient Member
210 Compression Spring
212 Semi-Resilient Member (Washer)
214 Belleville Washer
216 1st End
218 2nd End
220 1st Surface
222 2nd Surface
224 1st Connection Point
226 Through Bore
228 End Wall
230 3rd Surface
232 Driving Member 1st End
234 Driving Member 2nd End

236 Driving Member Shaft
237 Zig-zag/Sinusoidal/Helical-like Portion
238 Driving Member stop
240 2^{nd} Connection Point
242 2^{nd} Direction/Force
244 Collapsible/Compressible/Compactable Portion
246 Structural Portion
248 Interstitial Portion

What is claimed is:

1. A force damper arranged to progressively arrest a first force imparted by an object moving in a first direction, the force damper comprising:

a housing enclosure comprising a first housing end and a second housing end, the first housing end including a first connection point, and the second housing end including an opening;

a driving member disposed within the housing enclosure and comprising a first shaft end, a second shaft end, and a shaft therebetween, the first shaft end comprising a stop and the second shaft end comprising a second connection point; and,

a compressible member disposed within the housing enclosure between the stop and the opening, the compressible member exhibiting partial plastic deformation when the first force is arrested and imparting a second force on the stop toward the first housing end;

wherein, the driving member shaft includes an elongatable portion disposed between the first shaft end and the second shaft end, which is elongatable in the first direction upon application of sufficient force in the first direction to deform the elongatable portion;

wherein, the elongatable portion comprises one or more of a zig-zag region, a sinusoidal region, or a helical region;

wherein the elongatable portion is plastically deformable; and,

wherein the compressible member comprises a compression spring disposed around the shaft.

2. The force damper of claim **1**, further comprising a first and a second semi-resilient member, wherein the first semi-resilient member is disposed between a first terminal end of the compression spring and the stop, and the second semi-resilient member is disposed between a second terminal end of the compression spring opposite the first terminal end and an end wall of the second housing end.

3. The force damper of claim **1**, comprising the compression spring, a first semi-resilient member, and a Belleville washer, the second housing end opening comprising a through bore in an end wall thereof, and the second shaft end passes through the through bore.

4. The force damper of claim **3**, wherein the first semi-resilient member and the Belleville washer are disposed between the stop and the end wall.

5. The force damper of claim **4** comprising the first semi-resilient member and a second semi-resilient member, wherein the first semi-resilient member is disposed between a first terminal end of the compression spring and the stop, and the second semi-resilient member is disposed between a second terminal end of the compression spring opposite the first terminal end, and the end wall.

6. The force damper of claim **3**, wherein first the semi-resilient member comprises a urethane washer.

7. The force damper of claim **3**, wherein the Belleville washer is composed of one or more of a polymer, a metal, a frangible or fracturable material, or combinations thereof.

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