US010697575B2

(12) **United States Patent**
Conrad

(10) **Patent No.: US 10,697,575 B2**
(45) **Date of Patent: Jun. 30, 2020**

(54) **EXPANSION COMPENSATOR**

(71) Applicant: **Omachron Intellectual Property Inc.**, Hampton (CA)

(72) Inventor: **Wayne Ernest Conrad**, Hampton (CA)

(73) Assignee: **Omachron Intellectual Property Inc.**, Hampton, Ontario (CA)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 250 days.

(21) Appl. No.: **15/313,921**

(22) PCT Filed: **Jun. 16, 2015**

(86) PCT No.: **PCT/CA2015/050555**
§ 371 (c)(1),
(2) Date: **Nov. 23, 2016**

(87) PCT Pub. No.: **WO2015/196280**
PCT Pub. Date: **Dec. 30, 2015**

(65) **Prior Publication Data**

US 2017/0191597 A1 Jul. 6, 2017

(30) **Foreign Application Priority Data**

Jun. 26, 2014 (CA) 2855326
Jul. 25, 2014 (CA) 2857811

(51) **Int. Cl.**
F16L 51/02 (2006.01)
F16L 27/111 (2006.01)
F16L 51/00 (2006.01)

(52) **U.S. Cl.**
CPC ***F16L 51/027*** (2013.01); ***F16L 27/111*** (2013.01); ***F16L 51/02*** (2013.01); ***F16L 51/025*** (2013.01); *F16L 51/00* (2013.01)

(58) **Field of Classification Search**
CPC F16L 51/027; F16L 51/02; F16L 51/00; F16L 27/111; F16L 27/11; F16L 27/107
USPC 285/226–229, 419
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

337,037	A	2/1886	White
2,151,911	A	3/1939	Green et al.
2,565,296	A	8/1951	Chyle
2,645,249	A	7/1953	Davis et al.

(Continued)

FOREIGN PATENT DOCUMENTS

CA	2857811	C	1/2017
CN	2265469	Y	10/1997

(Continued)

OTHER PUBLICATIONS

English translation of CN202171086, as published on Mar. 21, 2012.

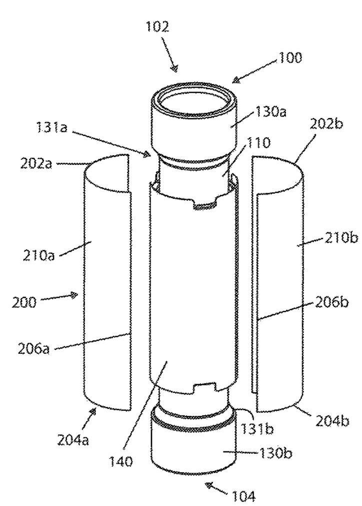
(Continued)

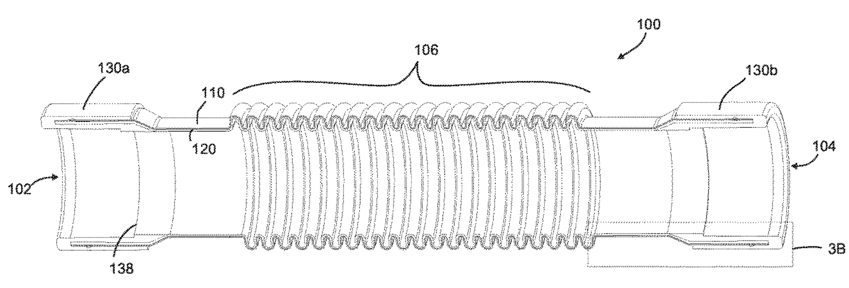
Primary Examiner — Anna M Momper
Assistant Examiner — Fannie C Kee
(74) *Attorney, Agent, or Firm* — Philip C. Mendes da Costa; Bereskin & Parr LLP/S.E.N.C.R.L., s.r.l.

(57) **ABSTRACT**

An expansion compensator are at least two axially extending elongate members, which combined, circumferentially extend around the expansion compensator while each elongate member individually circumferentially extends only part way around the expansion compensator.

11 Claims, 9 Drawing Sheets





(56) **References Cited**

U.S. PATENT DOCUMENTS

2,666,657	A *	1/1954	Howard	F16L 11/14 285/226
3,068,026	A *	12/1962	McKamey	F16L 39/005 285/123.1
3,183,022	A	5/1965	Sayag	
3,235,291	A	2/1966	Jacoby	
3,315,704	A	4/1967	Shire	
3,372,076	A	3/1968	Wilkinson	
3,623,339	A	11/1971	Muller	
3,655,224	A	4/1972	Carberry et al.	
3,747,367	A	7/1973	Muller	
3,807,777	A	4/1974	Larkin	
3,866,953	A	2/1975	Thastrup	
3,976,312	A	8/1976	Murphree	
4,054,158	A	10/1977	Hoeman et al.	
4,265,276	A	5/1981	Hatada et al.	
4,473,369	A *	9/1984	Lueders	A61M 39/1011 285/419
4,576,404	A	3/1986	Weber	
4,615,543	A *	10/1986	Cannon	F16L 35/00 166/241.4
4,643,463	A *	2/1987	Halling	F16L 27/0857 285/226
4,652,475	A	3/1987	Haney et al.	
4,683,917	A	8/1987	Bartholomew	
4,781,003	A	11/1988	Rizza	
4,864,711	A	9/1989	Yokota	
5,058,934	A	10/1991	Brannon	
5,284,184	A	2/1994	Noone et al.	
5,507,319	A	4/1996	Kanao	
5,554,426	A	9/1996	Röber et al.	
5,850,855	A	12/1998	Kerschbaumer et al.	
6,166,143	A	12/2000	Watanabe et al.	
6,293,311	B1	9/2001	Bushi et al.	
6,321,794	B1	11/2001	Ishida et al.	
6,386,240	B1	5/2002	Roeber et al.	
6,409,226	B1	6/2002	Slack et al.	
6,412,520	B1	7/2002	Yasumatsu et al.	
6,455,118	B1	9/2002	Dewimille et al.	
6,576,342	B1	6/2003	Cert et al.	
6,581,984	B1	6/2003	Seung-Kyu	
6,631,928	B1	10/2003	Sakata	
6,755,217	B1	6/2004	Yoshida	
6,848,719	B2	2/2005	Rowley	
6,880,861	B2	4/2005	Muroi et al.	
7,143,788	B2	12/2006	Keyes	
7,284,771	B2	10/2007	Baumann et al.	
8,291,943	B2	10/2012	Walle et al.	
2002/0195817	A1 *	12/2002	Choi	A62C 35/68 285/45
2004/0207201	A1	10/2004	Starita	
2004/0256017	A1	12/2004	Ari Ma	
2004/0256018	A1	12/2004	Ikemoto et al.	
2007/0227606	A1	10/2007	Sakazaki	
2008/0210329	A1	9/2008	Quigley et al.	
2009/0076595	A1	3/2009	Lindquist et al.	
2009/0139661	A1	6/2009	Frimel et al.	
2010/0244432	A1	9/2010	Neame et al.	
2011/0259040	A1	10/2011	Cataldo et al.	
2012/0216903	A1	8/2012	Osborne	
2013/0269819	A1	10/2013	Ruby et al.	
2014/0144540	A1	5/2014	Fiolek et al.	
2014/0299218	A1	10/2014	Hirth et al.	

FOREIGN PATENT DOCUMENTS

CN	101089446	A	12/2007
CN	202171086		3/2012
CN	202171086	U	3/2012
DE	3123625	A1	1/1983
EP	0789137	A2	8/1997
EP	1002982	A2	5/2000
EP	1010930		6/2000
EP	1010930	A1	6/2000
EP	0789137	A2	1/2002
GB	837559		6/1960
WO	97/18408		5/1997
WO	03/100311	A2	12/2003
WO	03100311	A2	12/2003
WO	2012/078842	A1	6/2012
WO	2013/135244	A1	9/2013
WO	2013/137745	A1	9/2013

OTHER PUBLICATIONS

English translation of CN101089446, as published on Dec. 19, 2007.
English translation of DE3123625, as published on Jan. 5, 1983.
English translation of WO03100311, as published on Dec. 4, 2003.
English translation of CN2265469, as published on Oct. 22, 1997.
English translation of EP1010930, as published on Jun. 21, 2000.
English translation of EP789137, as published on Jan. 16, 2002.
Abstract, Journal of Materials Processing Technology; "Superplasting forming of bellows expansion joints made of titanium alloys", vol. 178, Issues 1-3, Sep. 14, 2006, pp. 24-28.
The International Search Report and Written Opinion, as received in connection to international patent application No. PCT/CA2015/000161, dated Jun. 19, 2015.
The International Search Report and Written Opinion, as received in connection to international patent application No. PCT/CA2015/050555, dated Jul. 31, 2015.
The Office Action which issued in connection to corresponding OEE Canadian Patent No. 2,587,811, dated.
The Notice of Allowance which was received in connection to corresponding OEE Canadian U.S. Patent No. 2,587,811, dated Nov. 2, 2016.

* cited by examiner

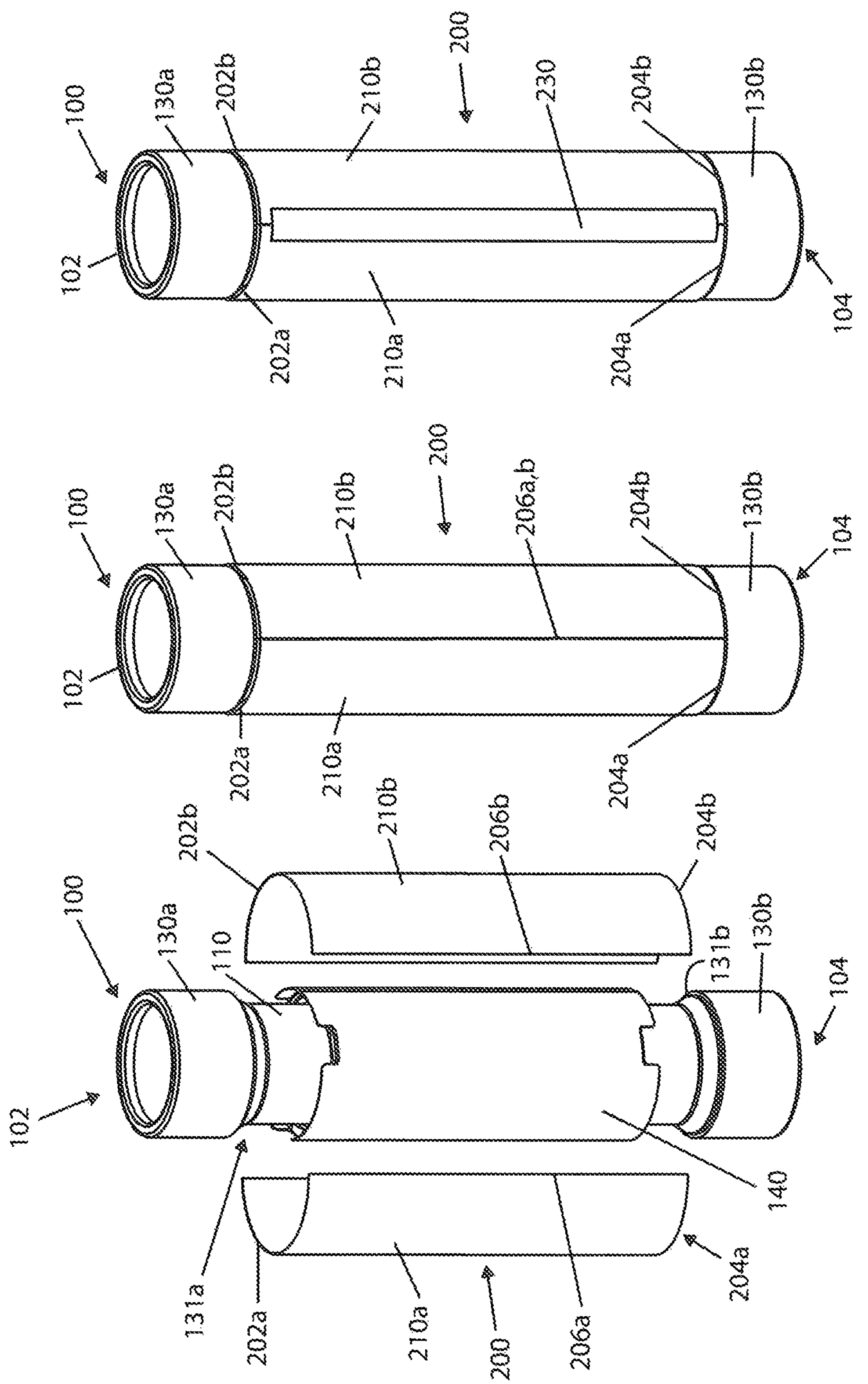


Figure 1A

Figure 1B

Figure 1C

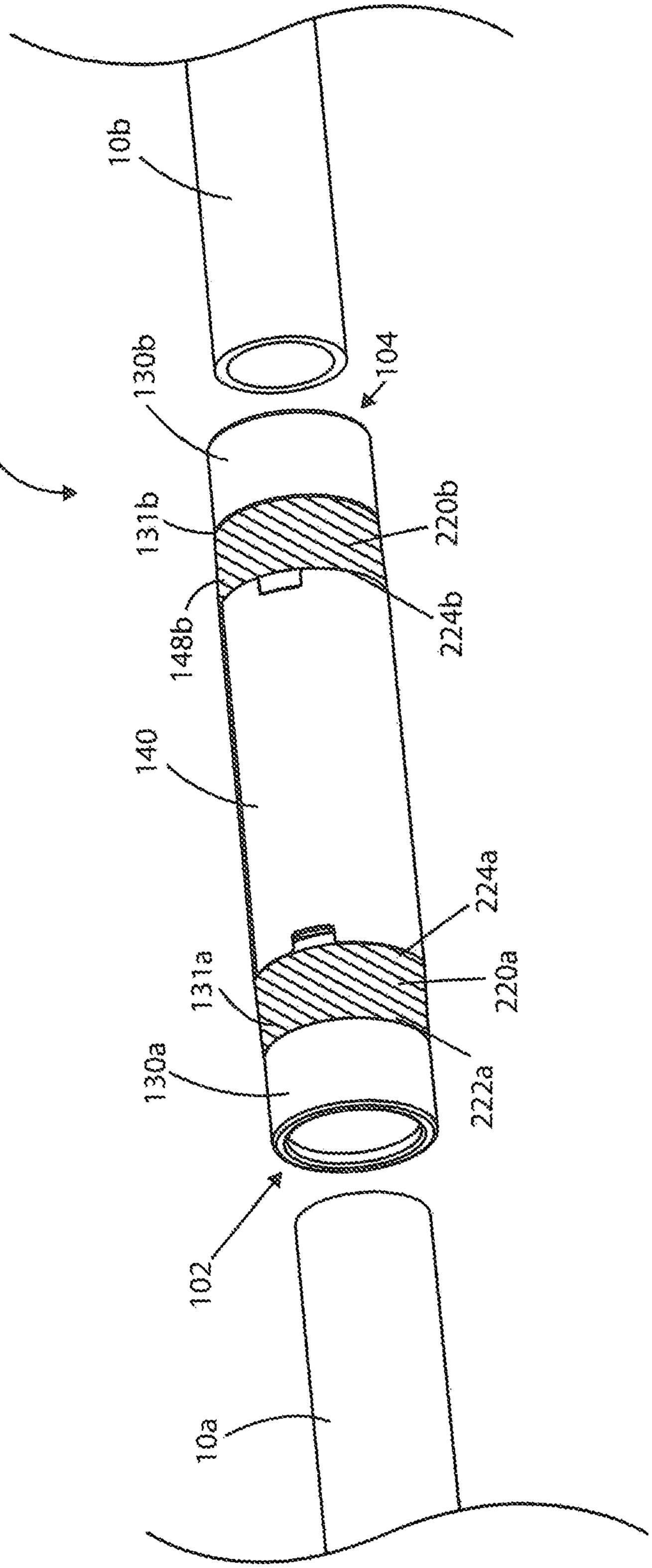

10b
100
130b
104
131b
220b
224b
148b
140
224a
131a
220a
130a
222a
102
10a

Figure 2A

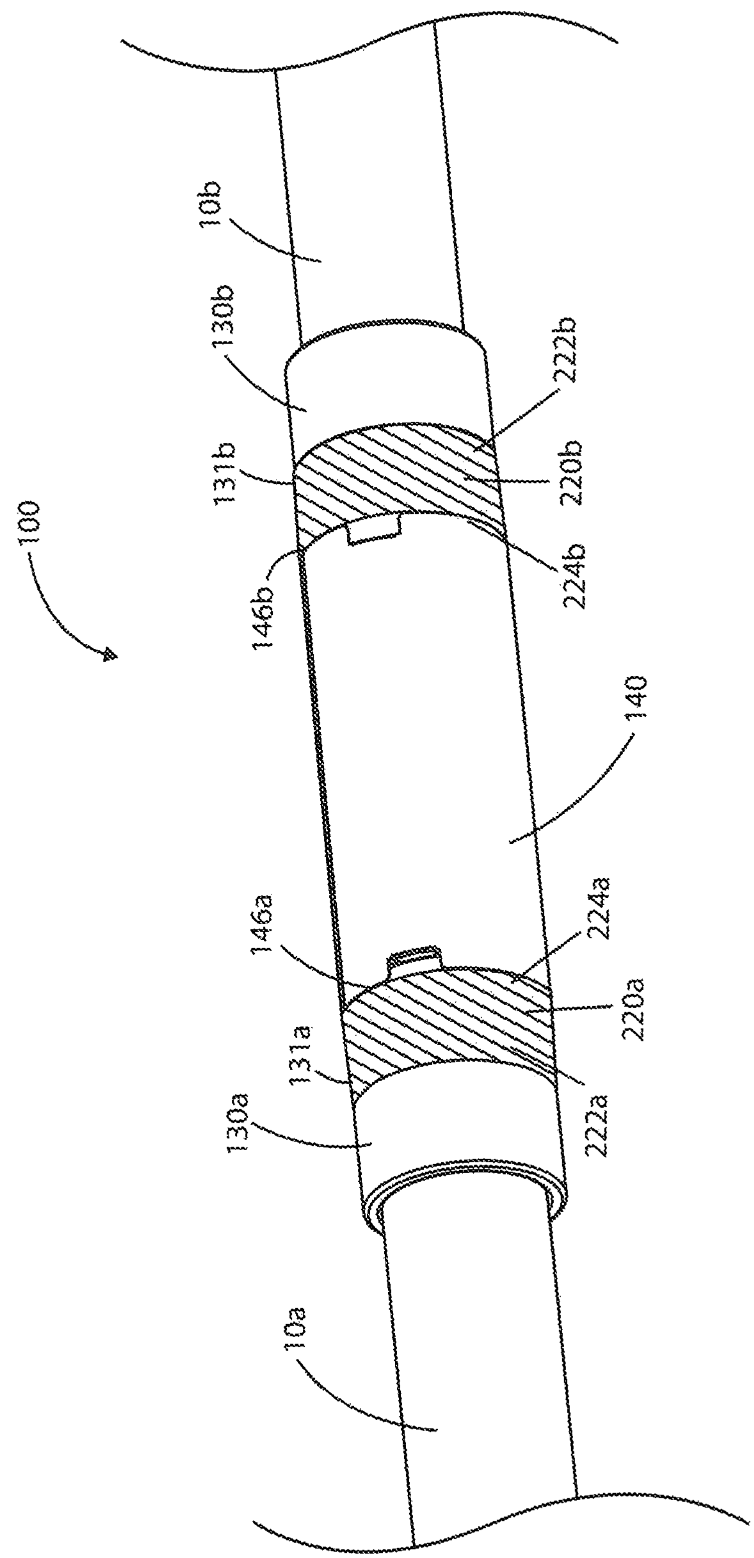

100
10b
130b
131b
222b
220b
224b
146b
140
146a
224a
220a
131a
130a
222a
10a

Figure 2B

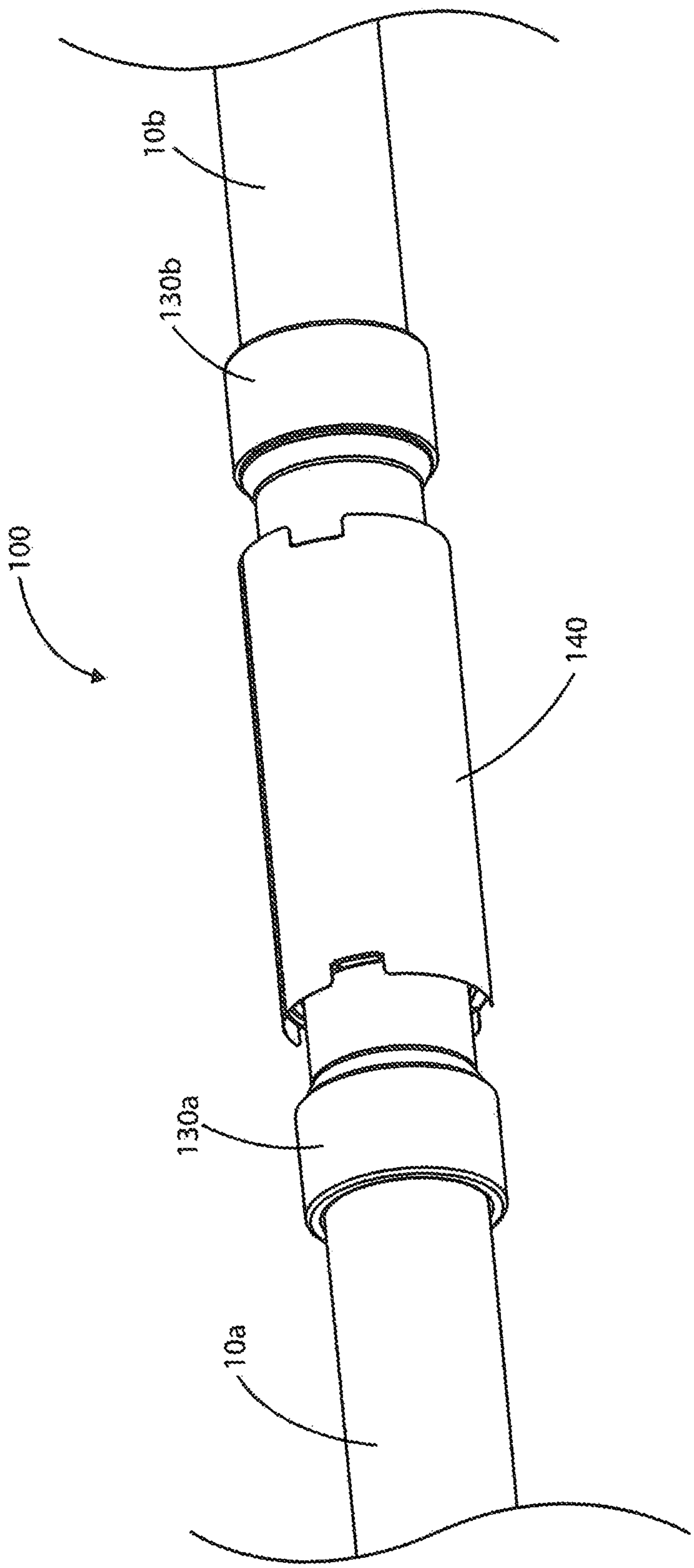


Figure 2C

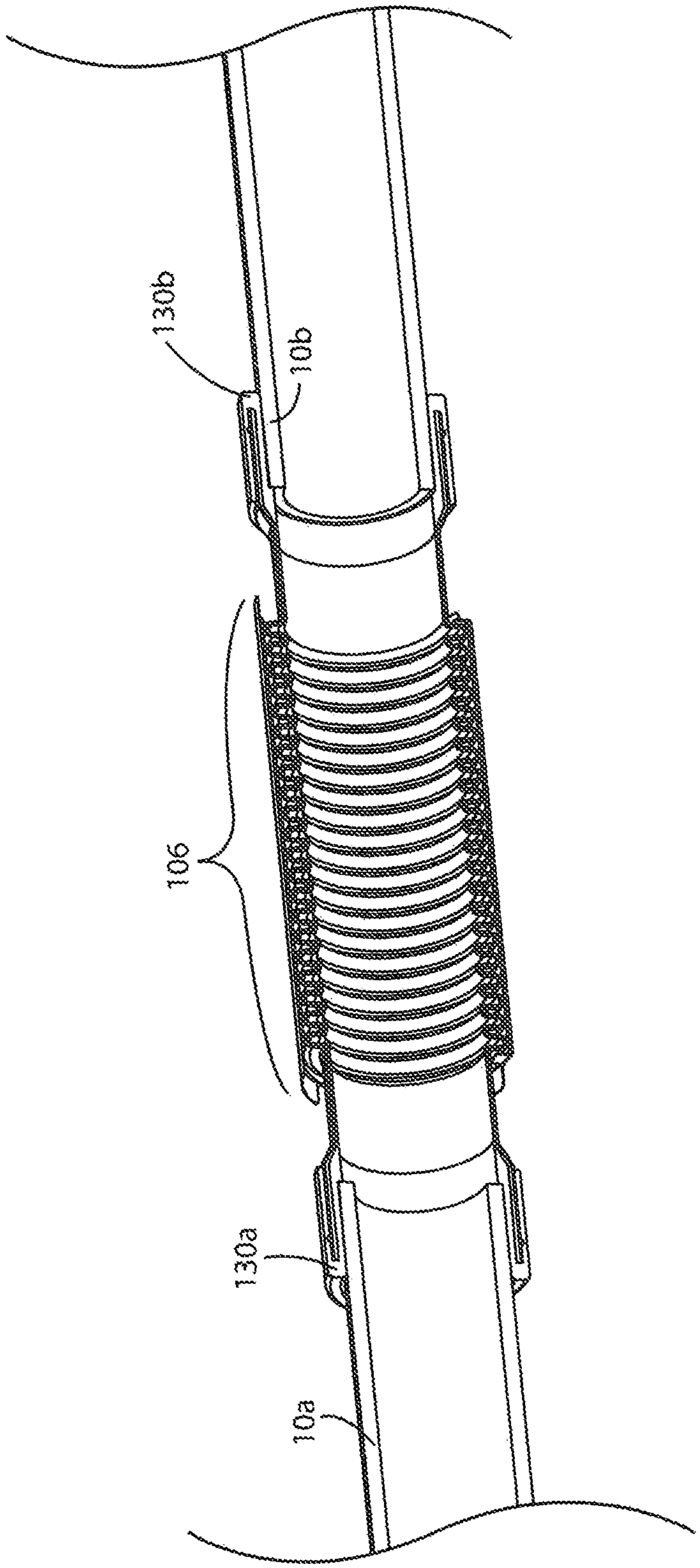


Figure 2D

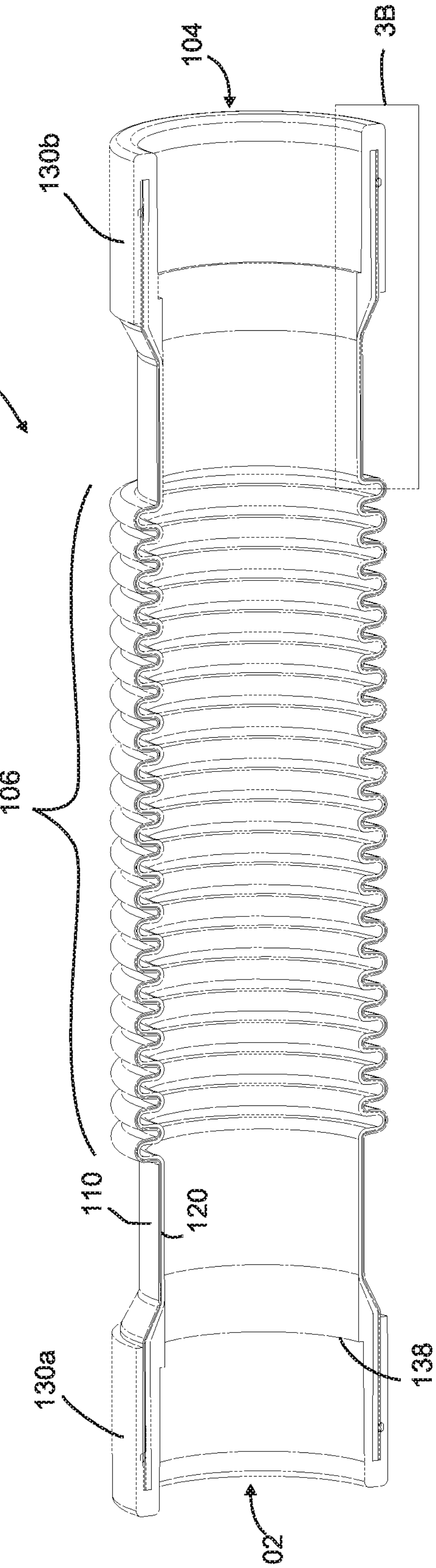


Figure 3A

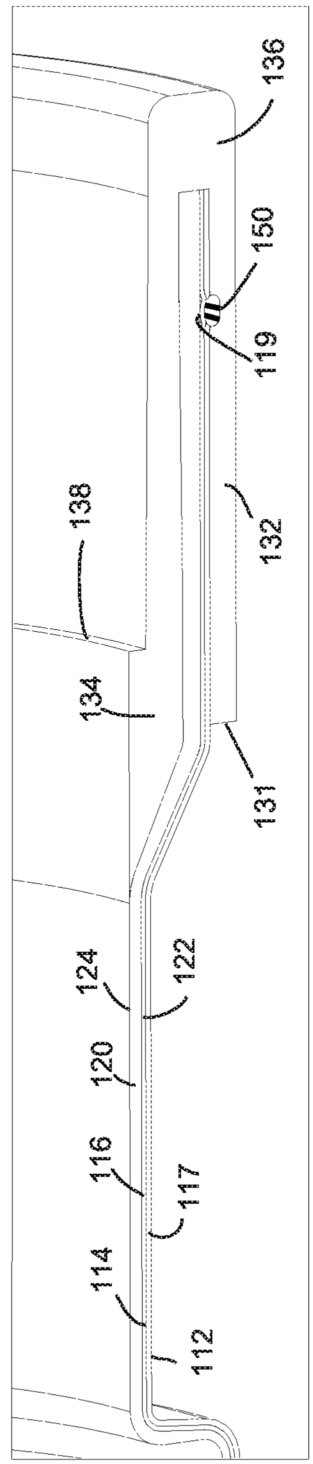


Figure 3B

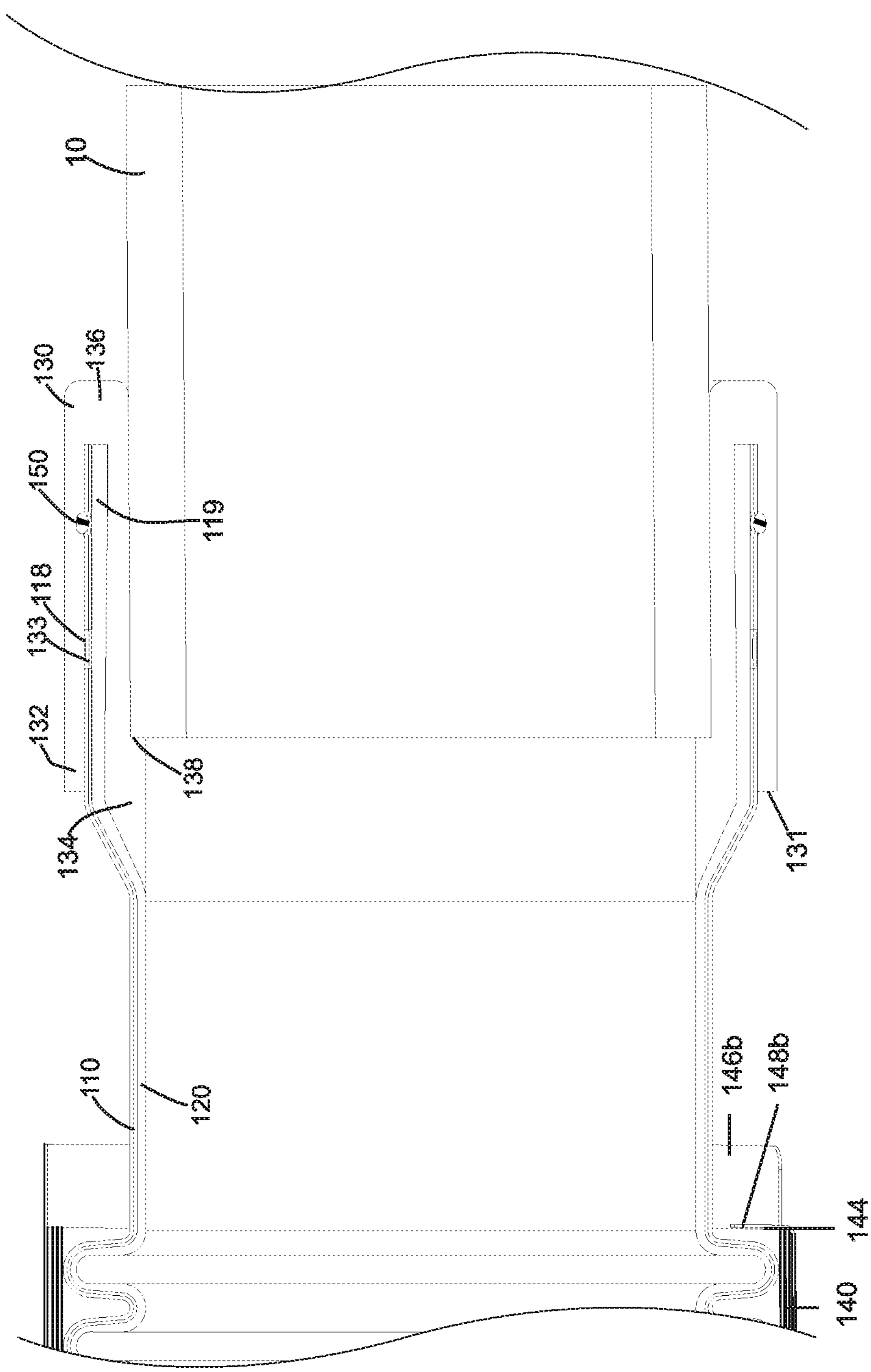

10
130
136
150
119
118
133
132
138
134
131
110
120
146b
148b
144
140

Figure 4

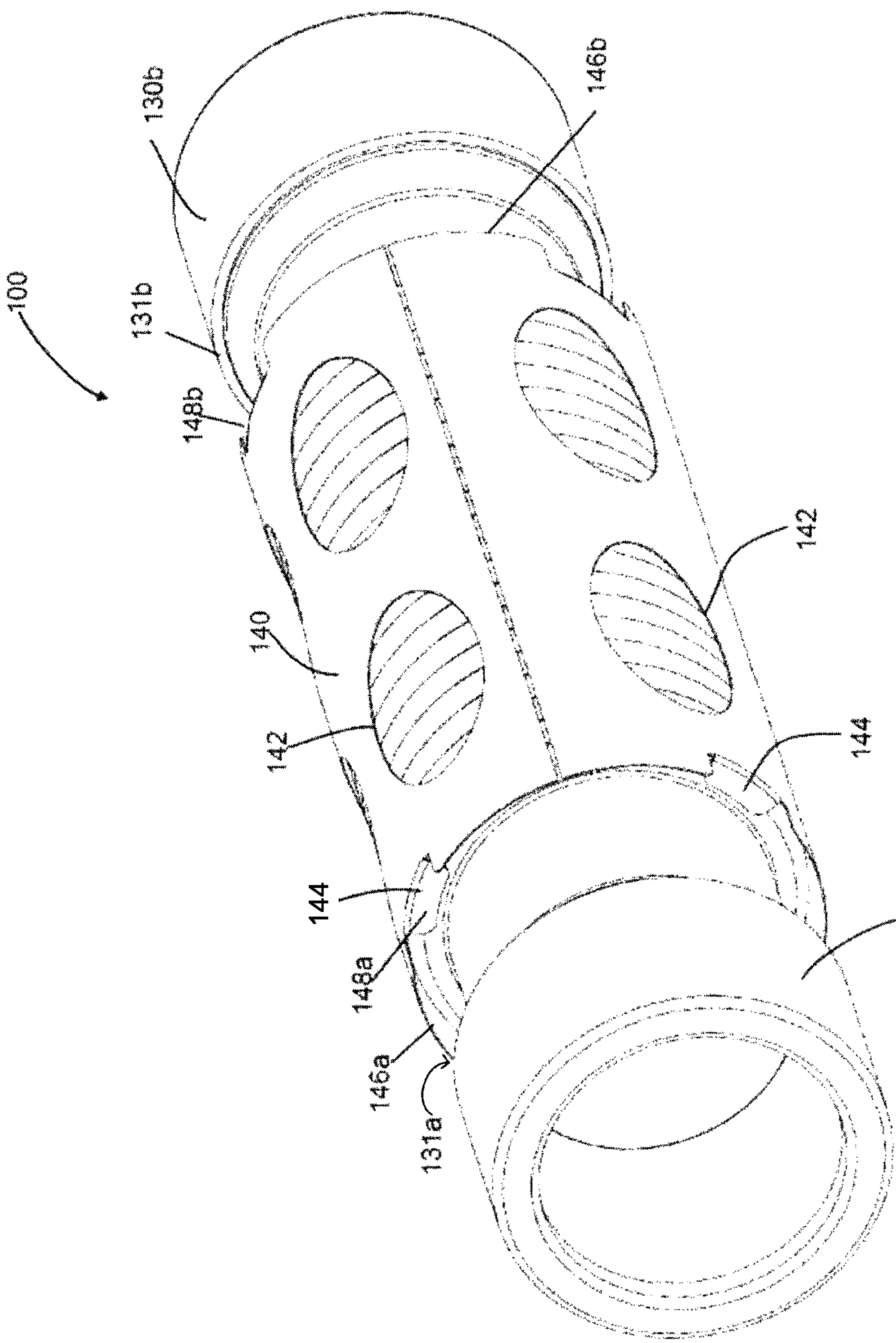

100
130b
146b
131b
148b
140
142
142
144
144
148a
146a
131a
130a

Figure 5A

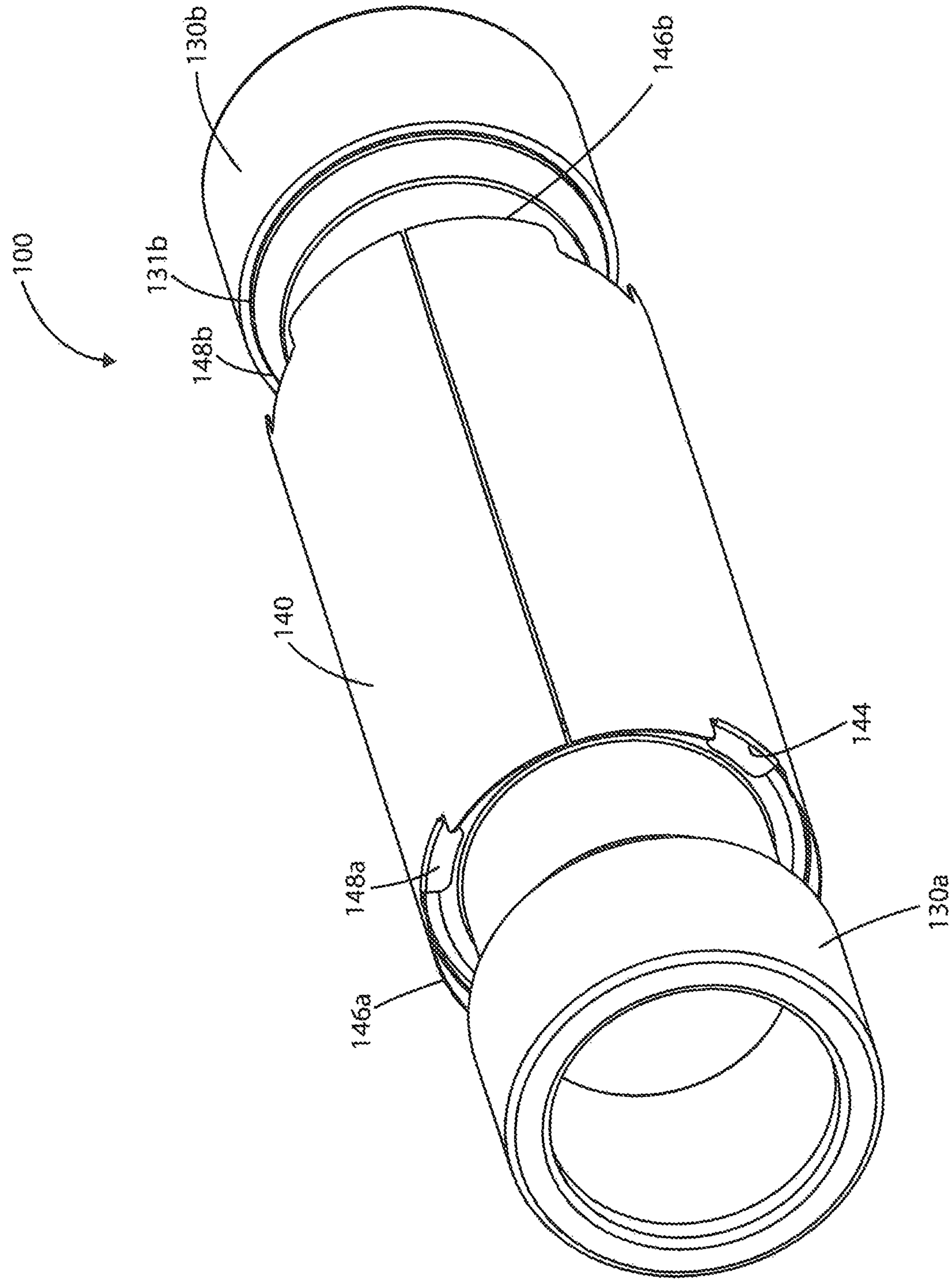


Figure 5B

EXPANSION COMPENSATOR

CROSS REFERENCE TO RELATED APPLICATIONS

This application claims benefit of 35 U.S.C. 371 based on co-pending international application No. PCT/CA2015/050555, filed Jun. 16, 2015, which itself claims priority from Canadian patent application 2,855,326 filed on Jun. 26, 2014 and Canadian patent application 2,857,811 filed on Jul. 25, 2014.

FIELD

This disclosure relates generally to an expansion compensator for connecting pipes and fittings that are used to convey a fluid, and more specifically to a method of installing an expansion compensator.

INTRODUCTION

Piping systems are used to convey liquids and/or gasses within, or between, residential, commercial, and/or industrial buildings. For example, most residential buildings have a potable water distribution system for providing cold and/or hot water at one or more locations within the building (e.g. sinks, showers, dish or clothes washing machines).

Typically, piping systems are made up of a number of components including straight or curved pipe sections, fittings (e.g. elbow fittings), valves, etc. to provide an interior flow path for the liquid being conveyed. Typically, a piping system (such as a system comprising thermoplastic pipes), is assembled such that the components are joined in a manner that provides a durable connection that prevents or inhibits the components from separating or cracking due to mechanical, thermal, and/or hydraulic stresses applied to the piping system. Separation of any of the components of the piping system or cracking of any element of the piping system may permit fluid to leak out of the piping system and, e.g., thereby damage the surrounding structure, e.g., the walls of a building which enclose the piping system.

Thermoplastic pipes (such as polyvinyl chloride (PVC) and/or chlorinated polyvinyl chloride (CPVC) pipes) may be subject to thermal expansion and/or contraction after installation. For example, a length of a thermoplastic pipe used for conveying fluid at an elevated temperature (e.g. hot water) may be subject to axial expansion and/or contraction based on the relative temperature of the fluid being conveyed, and the ends of the pipe may exert an axial force (either compressive or tensile) on the fittings, valves, or other parts of the piping system to which they are connected. Typically, hot water usage is intermittent. Therefore, hot water may be conveyed through a pipe for a period of time thereby heating the pipe. Subsequently, the flow of water will be terminated and the water in the pipe will cool as heat is dissipated to the ambient surrounding structure. This heating and cooling will cause the pipe to expand and contract axially. This cycle may be repeated several times a day or an hour. Continued thermal cycling of thermoplastic pipes (e.g., PVC and/or CPVC pipes) can result in a failure of the piping system and result in a leak.

Further, in a high rise building, plastic pipes that are mounted vertically to transport water between floors are mechanically constrained in their mechanical positions due to their mechanical attachment to transversely mounted pipes that deliver water horizontally to the various rooms or locations on the floors of the building. As such, when plastic pipes such as those made of PVC and CPVC are heated by the water that they transport, significant forces are created within the walls of the pipe due to the thermal expansion. These forces may exceed the buckling strength of the pipes, especially for pipe diameters under 6 inches, which may cause the plastic pipes to bend and/or buckle. This stress may result in a leak.

Once an installation is complete (e.g., the interior walls of a building are finished or a piping system is buried under a road), accessing the piping system to repair a leak is typically time consuming and expensive.

SUMMARY

The following introduction is provided to introduce the reader to the more detailed discussion to follow. The introduction is not intended to limit or define any claimed or as yet unclaimed invention. One or more inventions may reside in any combination or sub-combination of the elements or process steps disclosed in any part of this document including its claims and figures.

An expansion compensator may expand and/or contract in response to an applied axial force (compressive or tensile) that may arise from expansion and/or contraction of one or more lengths of pipe. For example, one or more such expansion compensators can be installed between a length of pipe and a fitting so that the axial forces that may be imposed on the pipe and/or the fitting due to thermal expansion and/or contraction of the length of pipe may be reduced. These axial forces may be borne by, or primarily borne by, or substantially borne by the expansion compensator and not by the pipe and/or the fitting. In the case in a high rise building (as compared to a house), each portion of the piping system that conveys hot water to each floor will be subjected to thermal expansion and contraction cycling. Without the use of an expansion compensator, the total expansion which may occur in the piping system carrying hot water to the top floor will be the aggregate of the expansion occurring for each floor of vertical rise, which may prevent the use of plastic piping.

Various types of expansion compensators may be used. Generally, an expansion compensator has at least a portion which may expand and contract as loads are applied thereto, such as loads due to thermal cycling from transporting a fluid. It will be appreciated that more than one portion may be provided that may expand and contract. For example, an expansion/contraction section may be provided at each end of an expansion compensator. Alternatively, the expansion/contraction section may extend along all or substantially all of the expansion compensator. An expansion compensator suitable for use with a plastic piping system may comprise an outer metal conduit and an inner plastic liner that are secured together.

In one embodiment, an expansion compensator suitable for use with a plastic piping system may comprise an outer metal conduit and an inner plastic liner wherein the inner plastic liner is secured to the outer metal conduit such that the outer metal conduit supports the inner plastic liner and absorbs stresses imposed on the inner plastic liner due to thermal cycling of the piping system. At least one, and preferably each end of the outer metal conduit and the inner plastic liner may be provided with a connector that may secure the outer metal conduit and the inner plastic liner together to provide a unitary body (i.e., so that together the outer metal conduit and the inner plastic liner act as a single body). The connector(s) may be provided by being overmolded over the end(s) of the outer metal conduit and the inner plastic liner.

In another embodiment, an expansion compensator suitable for use with a plastic piping system may comprise an outer metal conduit and an inner plastic liner wherein the outer metal conduit and the inner plastic liner may be secured together and wherein the axial stiffness of the metal conduit is greater than the axial stiffness of the inner plastic liner so that the outer metal conduit absorbs more (optionally a substantial portion or essentially all) of stresses imposed on the expansion compensator due to thermal cycling of the piping system. Accordingly, while axial forces imposed by a piping system may be borne by, or primarily borne by, or substantially borne by the expansion compensator, these axial forces may, in turn, be preferentially borne by (e.g., borne by, or primarily borne by, or substantially borne by) the outer metal conduit.

In one or both of these embodiments, the outer metal conduit and the inner plastic liner may be secured together such that fluid flowing in the piping system is not exposed to the outer metal conduit (e.g., the inner plastic liner defines the outer wall of the flow path through the expansion compensator from a pipe or fitting connected at one end of the expansion compensator to a pipe or fitting connected at the other end of the expansion compensator).

An advantage is that the fluid in the piping system is exposed only to the inner plastic liner. Accordingly, the outer metal conduit will not be exposed to the fluid, e.g., water, which may cause the metal to corrode over time. At the same time, the inner plastic liner is reinforced or supported by the outer metal conduit thereby reducing the stress imposed on the inner plastic liner and reducing the likelihood of the inner plastic liner cracking thereby resulting in a leak.

Another advantage is that by utilizing a metal conduit to reinforce the inner plastic liner, the expansion/contraction section (e.g., a bellows or accordion section) of the inner plastic liner may be made of a thinner material which increases the flexibility of the inner plastic liner and reduces the likelihood of the inner plastic liner cracking over time due to expansion and contraction caused by thermal cycling. In particular, since the inner plastic liner is reinforced or supported by the outer metal conduit, the axial forces imposed on the expansion compensator are preferentially absorbed by the outer metal conduit and the stress imposed on the inner plastic liner is reduced, which reduces the likelihood of the inner plastic liner cracking thereby resulting in a leak.

The pipe may be made of a plastic material known in the piping arts. The plastic material may be a thermoplastic material and may be one or more of acrylonitrile butadiene styrene (ABS), PVC, CPVC, ethylene vinyl acetate (EVA), polyethylene (PE), and the like. Preferred materials comprise PVC and/or CPVC.

An advantage of using such expansion compensators is that plastic piping may be used in installations requiring a long run of piping, such as in a high rise building. By providing one or more expansion compensators that will expand or contract in length due to thermal heating and cooling of the piping system, each fitting, e.g., a T-junction, may remain essentially static thereby increasing the reliability of the piping system and reducing the likelihood of a leak occurring.

Connectors that are compatible with typical thermoplastic piping system components (e.g., pipe ends; fittings such as valves, tees, couplers, elbows, and the like) may be provided at each end of the expansion compensator to facilitate its installation. For example, the connectors may be configured to accept typical pipe end dimensions, and for joining and/or sealing using typical means. Also, the expansion compensator may have an inner plastic liner made from the same (or similar) plastic material of the pipes to which it is to be installed, so that a fluid flowing through a pipe and expansion compensator will be in contact with the same (or similar) material through both components.

A piping system may be installed at a temperature of approximately 20° C. (e.g. at room temperature). In piping systems used for conveying fluid at an elevated temperature (e.g. hot water), the amount of thermal expansion of the pipes will depend at least in part on the difference between the installation temperature and the temperature of the conveyed fluid. For example, for a pipe installed at about 20° C. and used to convey hot water in a residential building (which is typically at a temperature of 70° C. to 83° C.), the degree of thermal expansion will be based on a temperature difference of approximately 50° C. to 63° C. Thus, an expansion compensator may be designed based on the expected compressive and tensile loads to be exerted (or imposed) due to thermal expansion or contraction based on such an expected temperature difference. However, if the piping is installed at a lower temperature due to, for example, the environmental temperature at the time of year the piping system is installed (e.g. during winter in a northern climate), the degree of thermal expansion will be based on a larger temperature difference (e.g. the thermal expansion of a pipe installed at about 0° C. and used to convey fluid at a temperature of 70° C. to 83° C. will be based on a temperature difference of approximately 70° C. to 83° C.). The resulting thermal expansion of the pipe may be larger than the expansion compensator and/or piping system was designed to accommodate.

Further, an expansion compensator will itself contract in lower temperatures. Put another way, at low temperatures an expansion compensator may be in a somewhat compressed state. Thus, an expansion compensator installed at low temperatures may have a reduced amount of travel (i.e. the amount the expansion/contraction section is able to compress may be lower) than if the expansion had been installed at a higher temperature. Once the piping system is operating, the expansion compensator will not be able to fully compress within its design specifications when a hot fluid flows through the piping system, which may compromise the operation of the expansion compensator

Also, while such an expansion compensator may be designed based on the forces expected to be imposed once the expansion compensator has been installed in a piping system (e.g. the expected compressive and tensile loads to be exerted (or imposed) due to thermal expansion or contraction of components of the piping system), an expansion compensator may also be subject to compressive and/or tensile loads during its installation in a piping system. For example, if a vertical section of pipe is installed in a multi-floor building, the weight of the vertically stacked pipes will apply a downward force to pipes and expansion compensators that are positioned lower in the vertical run. As a vertical run is installed, the pipes may be secured in position, such as by clamps or by horizontal runs of pipes (e.g., extending laterally from a T junction). Once installed, these securement members may absorb a sufficient amount of the weight of the piping system to prevent the upper portion of a piping system from compressing the expansion/contraction section(s) of an expansion compensator installed in the lower portion. However, until such securement members are installed, the weight of portions of a piping system installed above an expansion compensator may be sufficient to partially or fully compress the expansion/contraction section(s) of the expansion compensator.

Therefore, when the securement members are installed, the expansion/contraction section(s) of the expansion compensator will be fixed in a compressed position. Once the piping system is operating, the expansion compensator will not be able to fully compress within its design specifications when a hot fluid flows through the piping system, which may compromise the operation of the expansion compensator.

In addition, when coupling an end of an expansion compensator to a piping system using an insertion fit, an expansion compensator may be subject to higher compressive forces than would be expected due to thermal expansion or contraction. The application of loads in excess of a maximum rated load of an expansion compensator may damage the expansion compensator.

The possible damage to an expansion compensator as a result of the imposition of excessive loads during installation may present a number of challenges. For instance, damage to an expansion compensator during installation may not be apparent to a visual (or other) inspection of the installed expansion compensator. For example, the application of excessive installation loads may crack or otherwise damage the inner plastic liner without damaging the metal conduit, and it may be impractical to inspect the inner plastic liner once the expansion compensator has been installed in a piping system.

To prevent damage resulting from excessive installation loads, and/or to prevent an expansion compensator from being installed in a compressed position (e.g. due to being installed at a relatively low temperature, or due to the weight of portions of a piping system installed above an expansion compensator), an expansion compensator may be provided with an installation guard that inhibits or prevents axial compression of the expansion/contraction section of the expansion compensator during installation. After the expansion compensator has been installed in the piping system, the installation guard may be adjusted—e.g., such as by removing part or all of the guard, permitting portions of the guard to telescope or compress, or the like—to permit the designed axial compression of the expansion/contraction section to occur during operation of the piping system.

In accordance with this broad aspect, there is provided a method for installing an expansion compensator, the expansion compensator having a longitudinal axis and comprising first and second spaced apart ends, an expansion/contraction section located between the first and second spaced apart ends, a first connector provided at the first end, a second connector provided at the second end, and an installation guard operable to inhibit axial compression of the expansion/contraction section, the method comprising:

(a) coupling the first connector and the second connector to a piping system; and

(b) after the first connector and the second connector have been coupled to the piping system, adjusting the installation guard to permit axial compression of the expansion/contraction section during operation of the piping system.

In some embodiments, the installation guard is positioned exterior to the expansion/contraction section, the installation guard comprises a first end that abuts the first connector and a second axially spaced apart end that abuts the second connector, and step (b) comprises removing at least one of the first and second ends from abutment with its respective connector.

In some embodiments, step (b) comprises removing the installation guard from the expansion/contraction section.

In some embodiments, each of the expansion/contraction section and the installation guard have an axial stiffness, wherein during step (a) the axial stiffness of the installation guard is greater than the axial stiffness of the expansion/contraction section, and step (b) comprises modifying the installation guard to have an axial stiffness that is less than the axial stiffness of the expansion/contraction section.

In some embodiments, the installation guard is modified by removing material from the installation guard.

In some embodiments, the installation guard is modified by deforming the installation guard.

In some embodiments, the installation guard comprises at least two installation guard portions that are separable from each other and step (b) comprises removing at least one of the installation guard portions.

In some embodiments, the installation guard comprises at least two axially extending installation guard portions that are separable from each other, at least one of the installation guard portions comprises a first end that abuts the first connector and at least one of the installation guard portions comprises a second axially spaced apart end that abuts the second connector, and step (b) comprises removing at least one of the installation guard portions from abutment with one of the first and second connectors.

In some embodiments, the installation guard portions are secured to each other using a removable adhesive and step (b) comprises removing the adhesive whereby at least one of the installation guard portions is removed from abutment with one of the first and second connectors.

In some embodiments, the expansion compensator comprises a sleeve configured to inhibit lateral movement of the expansion/contraction section during use, the installation guard comprises a first installation guard portion configured to abut the first connector, a second installation guard portion configured to abut the second connector, and the sleeve is positioned intermediate the first and second installation guard portions and step (b) comprises removing at least one of the installation guard portions.

In some embodiments, step (a) comprises coupling the first connector and the second connector to a vertical section of the piping system.

In some embodiments, the expansion compensator may have a first coefficient of thermal expansion along the longitudinal axis, the installation guard may have a second, lower coefficient of thermal expansion along the longitudinal axis and the method may further comprise positioning the installation guard on the expansion compensator to inhibit axial compression of the expansion/contraction section due to thermal contraction of the expansion compensator.

In some embodiments, the expansion compensator may have a first coefficient of thermal expansion along the longitudinal axis, the installation guard may have a second, lower coefficient of thermal expansion along the longitudinal axis and the installation guard may be installed on the expansion compensator at a first temperature, and step (a) is conducted at a second temperature below the first temperature. The first temperature may be from about 15° C. to about 25° C., and the second temperature may be less than about 5° C.

In accordance with another broad aspect, there is provided an expansion compensator connectable in a piping system, the expansion compensator comprising:

(a) an elongate conduit having first and second spaced apart ends, an inner surface, an outer surface, and an expansion/contraction section and an interior volume extending from the first end to the second end;

(c) a first connector provided at the first end of the elongate conduit, the first connector having an opening in fluid communication with the interior volume of the inner plastic liner;

(d) a second connector provided at the second end of the elongate conduit, the second connector having an opening in fluid communication with the interior volume of the inner plastic liner; and,

(e) an installation guard operable to inhibit axial compression of the expansion/contraction section during installation.

In some embodiments, the installation guard is removably mounted to the expansion compensator.

In some embodiments, the installation guard is positioned exterior to the expansion/contraction section, the installation guard comprising a first end that abuts the first connector and a second axially spaced apart end that abuts the second connector.

In some embodiments, the installation guard is configured to be deformed following installation to enable compression of the expansion/contraction section during use of the piping system.

In some embodiments, at least a portion of the installation guard is removable from the expansion/contraction section.

In some embodiments, the installation guard comprises at least two discrete installation guard portions and at least one of the installation guard portions is removable from the expansion/contraction section.

In some embodiments, the installation guard portions are removably secured to each other.

In some embodiments, the installation guard portions are removably secured to each other using tape.

In some embodiments, the installation guard is made of cellulose.

In some embodiments, the expansion/contraction section may have a first coefficient of thermal expansion along the longitudinal axis, the installation guard may have a second, lower coefficient of thermal expansion along the longitudinal axis and the installation guard may be operable to inhibit axial compression of the expansion/contraction section due to thermal contraction of the expansion compensator.

In some embodiments, the installation guard also comprises a thermal compression guard.

In accordance with another broad aspect, there is provided an expansion compensator connectable in a piping system, the expansion compensator comprising:

(a) an elongate conduit having first and second spaced apart ends, an inner surface, an outer surface, and an expansion/contraction section and an interior volume extending from the first end to the second end;

(c) a first connector provided at the first end of the elongate conduit, the first connector having an opening in fluid communication with the interior volume of the inner plastic liner;

(d) a second connector provided at the second end of the elongate conduit, the second connector having an opening in fluid communication with the interior volume of the inner plastic liner; and,

(e) a thermal compression guard having a second, lower coefficient of thermal expansion operable to inhibit axial compression of the expansion/contraction section due to thermal contraction of the expansion compensator.

In some embodiments, the thermal compression guard may be mounted to the expansion compensator so as to inhibit thermal contraction of at least a portion of the expansion/contraction section when the expansion/contraction section is exposed to temperatures below room temperature.

In some embodiments, the thermal compression guard may be mounted to the expansion compensator so as to inhibit thermal contraction of the expansion/contraction section when the expansion/contraction section is exposed to temperatures below room temperature.

In some embodiments, the thermal compression guard may comprise a first end that abuts the first connector and a second axially spaced apart end that abuts the second connector.

In some embodiments, at least a portion of the thermal compression guard may be removable from the expansion/contraction section.

In some embodiments, the installation guard may comprise at least two discrete thermal compression guard portions and at least one of the thermal compression guard portions may be removable from the expansion/contraction section.

In some embodiments, the thermal compression guard portions may be removably secured to each other.

In some embodiments, the thermal compression guard portions may be removably secured to each other using tape.

In some embodiments, the thermal compression guard may be made of cellulose.

In some embodiments, the thermal compression guard may also comprise an installation guard operable to inhibit axial compression of the expansion/contraction section during installation.

In another aspect, an expansion compensator may be provided with an increased ability to absorb compressive forces be stretching the expansion compensator (the expansion/contraction or bellows section) prior to installing a guard. Accordingly, the expansion/contraction section will be able to contract a greater amount once the guard is removed.

In accordance with this aspect, there is provided an expansion compensator connectable in a piping system, the expansion compensator comprising:

(a) an elongate conduit having first and second spaced apart ends and an expansion/contraction section, the expansion/contraction section being reconfigurable between a neutral configuration and a stretched configuration;

(c) a first connector provided at the first end of the elongate conduit, the first connector having an opening in fluid communication with an interior volume of the elongate conduit;

(d) a second connector provided at the second end of the elongate conduit, the second connector having an opening in fluid communication with an interior volume of the elongate conduit; and,

(e) a guard positioned to maintain the expansion/contraction section in the stretched configuration.

It will be appreciated by a person skilled in the art that a method or apparatus disclosed herein may embody any one or more of the features contained herein and that the features may be used in any particular combination or sub-combination.

These and other aspects and features of various embodiments will be described in greater detail below. The apparatus and methods described herein may be used to connect pipes and/or fittings of various materials (e.g. metallic pipes, thermoplastic pipes) to create piping systems for transporting various liquids or gasses. It will be appreciated that the piping system that uses the expansion compensator may be made from different materials (e.g., the pipes may be made of PVC and/or CPVC and the fittings may be made of metal). Alternatively, the piping system components (or at least their inner surfaces through which fluid is conveyed) may be made of the same material.

Furthermore, the apparatus and methods may be applied to different sizes of piping, and/or piping systems made of the same or different materials, and therefore may be applicable to piping systems for domestic or commercial uses, such as conveying potable water, non-potable or waste water, or other liquids and/or gasses.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the described embodiments and to show more clearly how they may be carried into effect, reference will now be made, by way of example, to the accompanying drawings in which:

FIG. **1**A is a perspective view of an expansion compensator with an installation guard positioned for installation in accordance with one embodiment;

FIG. **1**B is a perspective view of the expansion compensator and installation guard of FIG. **1**A with the installation guard positioned to inhibit axial compression of an expansion/contraction section of the expansion compensator;

FIG. **1**C is a perspective view of the expansion compensator and installation guard of FIG. **1**B with the installation guard portions removably secured to each other using tape;

FIG. **2**A is a perspective view of an expansion compensator, which has a pair of installation guards, disposed between two pipe ends;

FIG. **2**B is a perspective view of the expansion compensator, installation guards, and pipe ends of FIG. **2**A with the pipe ends received in the connectors of the expansion compensator;

FIG. **2**C is a perspective view of the expansion compensator of FIG. **2**A with the pipe ends received in the connectors of the expansion compensator and the installation guards removed so as to reveal a sleeve;

FIG. **2**D is a longitudinal cross section view of FIG. **2**C,

FIG. **3**A is a cross section view of an expansion compensator in accordance with one embodiment;

FIG. **3**B is an enlarged view of the box **3**B in FIG. **3**A of the expansion compensator of FIG. **3**A;

FIG. **4** is a cross section view of an end of the expansion compensator of FIG. **3**A joined to a pipe end;

FIG. **5**A is a perspective view of an expansion compensator with a sleeve; and,

FIG. **5**B is a perspective view of the expansion compensator of FIG. **5**A with an alternate sleeve.

The drawings included herewith are for illustrating various examples of articles, methods, and apparatuses of the teaching of the present specification and are not intended to limit the scope of what is taught in any way.

DESCRIPTION OF EXAMPLE EMBODIMENTS

Various apparatuses, methods and compositions are described below to provide an example of an embodiment of each claimed invention. No embodiment described below limits any claimed invention and any claimed invention may cover apparatuses and methods that differ from those described below. The claimed inventions are not limited to apparatuses, methods and compositions having all of the features of any one apparatus, method or composition described below or to features common to multiple or all of the apparatuses, methods or compositions described below. It is possible that an apparatus, method or composition described below is not an embodiment of any claimed invention. Any invention disclosed in an apparatus, method or composition described below that is not claimed in this document may be the subject matter of another protective instrument, for example, a continuing patent application, and the applicant(s), inventor(s) and/or owner(s) do not intend to abandon, disclaim, or dedicate to the public any such invention by its disclosure in this document.

The apparatuses, methods and compositions may be used with piping systems made of various materials. The pipes and/or fittings to be connected may be made of a plastic material and optionally a thermoplastic material. The thermoplastic material may be one or more of acrylonitrile butadiene styrene (ABS), PVC, CPVC, ethylene vinyl acetate (EVA), polyethylene (PE) or the like. Preferably, the thermoplastic material is one or more of PVC and CPVC.

The drawings exemplify the use of the expansion compensator to connect sections of pipe together. It will be appreciated that the same expansion compensator may be used to connect any parts of a piping system together. For example, the expansion compensator may be used to connect a pipe with a fitting such as a valve, tees, couplers, elbows and the like, or to connect one fitting with another fitting.

FIGS. **3**A to **5**B exemplify different embodiments of an expansion compensator **100**, each of which may be installed according to the methods disclosed herein. An expansion compensator **100** may include an elongate metal conduit, referred to generally as **110**, interior to which is positioned an inner plastic liner **120** that provides a fluid flow path through the expansion compensator **100**. Also, first and second connectors **130***a,b* may be provided at opposite ends of the metal conduit and plastic liner. Connectors **130***a,b* may be used for coupling the expansion compensator to a piping system, as will be discussed further subsequently.

Methods for manufacturing expansion compensator **100** are described in Canadian patent applications 2,847,520 and 2,847,536 filed on Mar. 25, 2014, the disclosure of which is incorporated herein by reference. Constructions of expansion compensators are described in Canadian patent applications 2,846,801 filed on Mar. 17, 2014 and U.S. Pat. No. 2,846,921 filed on Mar. 18, 2014, the disclosure of which is incorporated herein by reference.

As exemplified in FIG. **3**A, expansion compensator **100** comprises a first end **102**, a second end **104**, and an expansion/contraction section **106**. Expansion/contraction section **106** allows for the axial length of expansion compensator **100** to vary in response to an applied axial force (either compressive or tensile). For example, if the position of first end **102** is fixed, and an axial force is applied to second end **104** in a direction towards first end **102**, expansion/contraction section **106** may contract in the axial direction, reducing the axial length of expansion compensator **100**. Also, if the position of first end **102** is fixed, and an axial force is applied to second end **104** in a direction away from first end **102**, expansion/contraction section **106** may expand in the axial direction, increasing the axial length of expansion compensator **100**. While expansion/contraction section **106** is illustrated as a bellows section having a series of convolutions, it will be appreciated that other geometric configurations such as sinusoidal or otherwise articulated surface may be used. These constructions permit the expansion compensator to temporarily deform (e.g., elastically deform) axially inwardly and outwardly during thermal expansion and contraction of the piping system, without fracture of the expansion compensator.

Still referring to FIG. **3**A, the main body of expansion compensator **100** comprises elongate metal conduit **110**, within which is positioned inner plastic liner **120**. Preferably, the opposite ends of metal conduit **110** and inner plastic liner **120** are coupled together to provide a unitary body (i.e., so that the respective ends of the outer metal conduit and the inner plastic liner axial will have the same relative displacement in response to an applied axial force). In such an arrangement, metal conduit **110** and inner plastic liner **120** may be characterized as springs acting in parallel. Thus, the overall axial stiffness of expansion compensator **100** (e.g. k_{EC}) may be approximated as the sum of the axial stiffness of metal conduit **110** (e.g. k_{MC}) and the axial stiffness of inner plastic liner **120** (e.g. k_{IPL}):

$$k_{EC} \cong k_{MC} + k_{IPL} \tag{1}$$

It follows that where the axial stiffness of the elongate metal conduit is greater than the stiffness of the inner plastic liner, a greater portion (preferably a substantial portion, and most preferably substantially all) of an axial force applied to expansion compensator **100** will be borne (e.g. absorbed) by metal conduit **110**, while inner plastic liner **120** will bear a smaller portion (preferably a significantly smaller portion) of the applied axial force. Put another way, to balance (e.g. reach equilibrium with) an axial force F_{EC} applied to expansion compensator **100**, and assuming a common axial displacement −x (i.e. compression), the magnitude of the force exerted by each of metal conduit **110** (F_{MC}) and inner plastic liner **120** (F_{IPL}) will be proportional to their respective stiffness:

$$\begin{aligned} F_{EC} &= F_{MC} + F_{IPL} \\ &= (k_{MC} \cdot -x) + (k_{IPL} \cdot -x) \\ &= (k_{MC} + k_{IPL})(-x) \end{aligned} \tag{2}$$

For example, if the axial stiffness k_{MC} is four times greater than the axial stiffness k_{IPL}, metal conduit **110** will provide about 80% of the total force exerted by expansion compensator **100** in response to an applied axial force.

While the stiffer metal conduit **110** may absorb the majority of an applied axial force, inner plastic liner **120** may provide a barrier between the metal conduit and a fluid flowing through expansion compensator **100**. For example, inner plastic liner **120** may protect metal conduit **110** from corrosive or otherwise reactive fluids, extending the lifespan of metal conduit **110** and/or preventing portions of metal conduit **110** from leaching into fluids flowing through expansion compensator **100**. Preferably, the expansion compensator has an inner plastic liner made from the same (or similar) thermoplastic material of the pipes to which it is to be installed, so that a fluid flowing through a pipe and expansion compensator will be in contact with the same (or similar) material through both components.

Metal conduit **110** may be made from steel, copper, or other iron alloys, or any other metal used in the piping arts although it will be appreciated that other metallic materials may be suitable. Preferably, metal conduit **110** is made from one or more layers of stainless steel, such as SS316L stainless steel.

As exemplified in FIG. **3**B, metal conduit **110** comprises an inner elongate metal conduit **116** and an outer elongate metal conduit **117**, together with inner plastic liner **120** forming a three-layer expansion compensator. Where metal conduit **110** comprises more than one metal layer, it will be appreciated that the overall axial stiffness of metal conduit **110** may be approximated as the sum of the axial stiffness for each metal layer. In such a case, inner elongate metal conduit **116** and outer elongate metal conduit **117** may have the same stiffness or they may be different. It will also be appreciated that inner elongate metal conduit **116**, outer elongate metal conduit **117** and inner plastic liner **120** may be abutting as exemplified in FIG. **3**B or they may be spaced apart. In some embodiments, in order to reduce friction a lubricant may be provided between inner elongate metal conduit **116** and inner plastic liner **120**.

In embodiments where metal conduit **110** comprises two layers, the thickness of each metal conduit **116**,**117** may be from 0.005 to 0.025 inches, preferably from 0.008 to 0.020 inches, and more preferably from 0.012 to 0.016 inches.

Alternatively, metal conduit **110** and inner plastic liner **120** may each comprise a single layer, together forming a two-layer expansion compensator. For these embodiments, the thickness of metal conduit **110** may be from 0.005 to 0.050 inches, preferably from 0.010 to 0.020 inches, and more preferably from 0.012 to 0.016 inches. The thickness of inner plastic liner **120** may be from 0.005 to 0.125 inches, preferably from 0.020 to 0.1 inches, and more preferably from 0.040 to 0.090 inches.

It will be appreciated that the stiffness of expansion compensator **100** may vary based on the number of metal layers in metal conduit **110**, the particular metal or metals used, the thickness of each metal layer, and/or the geometry of metal conduit **110**. The stiffness of expansion compensator **100** may also depend on the number of layers in inner plastic liner **120**, the particular plastic or plastics used, the thickness of each plastic layer, and/or the geometry of inner plastic liner **120**.

In FIG. **3**A, expansion/contraction section **106** is generally illustrated as a bellows section having a series of convolutions. While the expansion/contraction sections of metal conduit **110** and inner plastic liner **120** are shown with complementary profiles (e.g. each have a similar profile, and these profiles are aligned), it will be appreciated that that this need not be the case. For example, metal conduit **110** and inner plastic liner **120** may have different profiles and/or the profiles need not be aligned.

Where inner plastic liner **120** comprises more than one plastic layer, it will be appreciated that the overall axial stiffness of inner plastic liner **120** may be approximated as the sum of the axial stiffness for each plastic layer. In such a case, each plastic layer may have the same stiffness or they may be different. It will also be appreciated that each plastic layer may be abutting or one or more may be spaced apart.

In embodiments where inner plastic liner **120** comprises two layers, the thickness of each plastic layer may be from 0.005 to 0.075 inches, preferably from 0.020 to 0.050 inches, and more preferably from 0.03 to 0.045 inches.

It will be appreciated that metal conduit **110** and inner plastic liner **120** may be abutting as exemplified in FIG. **3**B or they may be spaced apart. That is, while outer surface **122** of inner plastic liner **120** is illustrated as being in contact with (e.g. abutting) inner surface **114** of metal conduit **110**, it will be appreciated that in some embodiments, an air gap may be present along all or part of the length of expansion compensator **100**. In some embodiments, in order to reduce friction a lubricant may be provided between metal conduit **110** and inner plastic liner **120**. The lubricant may be any lubricant that is compatible with the inner plastic liner and metal conduit and may be talcum powder, powdered Teflon, powdered mica and the like.

In other embodiments, expansion compensator **100** may comprise additional layers. For example, a protective layer (not shown) may be disposed between metal conduit **110** and inner plastic liner **120**. Such a protective layer may serve to reduce friction between metal conduit **110** and inner plastic liner **120** during expansion and/or contraction of expansion compensator **100**. Also, such a protective layer may provide an additional 'failsafe' layer to prevent leakage of fluid from within expansion compensator **100** (e.g. should one or more cracks develop in inner plastic liner **120** and/or metal conduit **110**).

The protective layer may be located between metal conduit **110** and inner plastic liner **120** and may abut a surface or may be spaced from the facing surfaces. For example, a protective layer may be provided: as a coating on outer surface **122** of inner plastic liner **120**; as a coating on inner surface **114** of elongate metal conduit **110**; and/or as a separate layer positioned between metal conduit **110** and plastic liner **120** during manufacture of expansion compensator **100**.

Preferably, the protective layer is made from polytetrafluoroethylene (PTFE) or one or more other suitable fluoropolymers, although it will be appreciated that other materials may be used.

The elongate metal conduit **110** and the inner plastic liner **120** may be coupled together by providing a connector **130** at one and preferably each end of the expansion compensator. As shown in FIG. **3**B, metal conduit **110** (illustrated here as comprising an inner elongate metal conduit **116** and an outer elongate metal conduit **117**) has an outer surface **112** and an inner surface **114**. Inner surface **114** is adjacent an outer surface **122** of inner plastic liner **120**, while inner surface **124** of inner plastic liner **120** defines the interior volume of expansion compensator **100** between connectors **130***a,b*.

As exemplified in FIG. **3**B, each connector **130** is secured to each of metal conduit **110** and inner plastic liner **120** to thereby secure metal conduit **110** and inner plastic liner **120** together. As exemplified, connector **130** may have a first portion or arm **132** secured to the outer surface **112** of elongate metal conduit **110**, and a second portion or arm **134** secured to the inner surface **124** of inner plastic layer **120**. In the illustrated embodiment, first portion **132** and second portion **134** are connected via an end portion **136**, such that connector **130** defines a generally U-shaped cavity between portions **132**, **134**, and **136**.

Also, each connector **130** may have one or more surfaces **131** that generally face towards the other end of expansion compensator **100**. While in the illustrated embodiments inwardly-facing surface **131** extends continuously around expansion compensator **100**, it will be appreciated that in variant embodiments one or more discontinuous inwardly facing surfaces may be provided on connector **130**.

In some embodiments, as shown in FIG. **4**, the ends of metal conduit **110** may be provided with a plurality of openings **118**. These openings may assist in securing connectors **130***a,b* to respective ends of expansion compensator **100**. Also, engagement of connector **130** and openings **118** in metal conduit **110** may allow a greater portion of an axial force applied to connector **130** to be transferred to metal conduit **110**, rather than to inner plastic liner **120**.

For example, openings **118** may allow a portion of first portion **132** of connector **130** to project into metal conduit **110**, which may provide a more robust connection between metal conduit **110** and connector **130**. These connecting portions **133** extending through openings **118** may be provided by, for example, overmolding portions **132**, **134**, and **136** of connector **130** onto the ends of metal conduit **110** and inner plastic liner **120**. An advantage of connecting portions **133** is that connecting portions **133** extend at about 90° to the axial forces that are expected to be exerted on expansion compensator **100** by thermal cycling. Thus, the axial forces that are applied to expansion compensator **100** may be transferred to metal conduit **110** via connectors **130***a,b*, and not via inner plastic liner **120**.

As noted previously, if elongate metal conduit **110** comprises inner elongate metal conduit **116** and outer elongate metal conduit **117**, then each metal conduit **116**, **117** may be provided with openings **118**. Accordingly, even if two metal conduits **116**, **117** are used, connecting portions **133** may extend from portion **132** through both metal conduits **116**, **117** to be secured to inner plastic liner **120**, which itself may be secured to portion **134** of connector **130**, such as by heating to form a unitary body, an adhesive or the like.

An advantage of forming connecting portions **133** by overmolding, is that portions **132**, **134** of connector **130**, connecting portions **133** and inner liner **120** may be formed essentially as a unitary body (e.g., the plastic that is used to overmold will heat inner liner **120** and may melt a sufficient amount of inner liner **120** to be secured thereto). Metal conduit **110** may therefore be embedded therein and securely fixed in position and thereby be adapted to incur axial stresses applied by thermal cycling.

Alternatively, connectors **130** may be formed with projections on the inner surface of first portion **132** sized and located to be received in openings **118** and act as connecting portions **133** when connector **130** is mounted (e.g. press-fit or snapped on to) an end **102**, **104** of metal conduit **110**. In this latter case, the connecting portions **133** may be secured to inner plastic liner **120** by, e.g., an adhesive, welding or the like. Optionally, inner plastic liner **120** may be secured to portions **134** of connector **130** in a similar manner.

Optionally, the ends of metal conduit **110** may be provided with one or more surface features (e.g. radial ridges or grooves) to facilitate the installation of a gasket between metal conduit **110** and outer portion **132** of connector **130**. For example, as shown in FIG. **3**B, a radial groove **119** may be provided on outer surface **112** of an end of metal conduit **110**, radial groove **119** being configured to receive a gasket such as an O-ring **150**. Such a gasket may be provided to minimize the chance of fluid leaking from expansion compensator **100** via, e.g., a gap between inner surface **124** of inner plastic liner **120** and second portion **134** of connector **130**, between the ends of metal conduit **110** and inner plastic liner **120** and end portion **136** of connector **130**, and between outer surface **112** of metal conduit **110** and first portion **132** of connector **130**. Radial groove **119** may assist in locating and retaining O-ring **150** relative to the end of expansion compensator **100** as connector **130** is mounted and/or molded to an end **102**, **104** of metal conduit **110**. It will be appreciated that a gasket may be provided in the absence of a groove **119**.

Accordingly, prior to overmolding (or otherwise providing) one or more connectors **130**, one or more gaskets (e.g. O-ring **150**) may be installed on the ends of metal conduit **110** (e.g. in one or more grooves **119**) prior to overmolding the connectors.

Additionally, or alternatively, the outer surface **112** of metal conduit **110** (and/or the inner surface of inner plastic liner **120**) at the ends of expansion compensator **100** may be subject to a surface treatment prior to overmolding, to improve the connection between metal conduit **110** and/or inner plastic liner **120** and connectors **130**.

As illustrated in FIG. **5**A, expansion compensator **100** may be provided with a sleeve **140**. Sleeve **140** may overlie some and preferably all or essentially all of expansion/contraction section **106** to protect against damage, restrain deflection of expansion/contraction section **106** in a radial or lateral direction, and/or provide a distinctive aesthetic appearance to expansion compensator **100**. For example, expansion/contraction section **106** of expansion compensator **100** may have a corrugated exterior surface. This surface might get caught (which could cause damage to the expansion compensator) as a pipe with the expansion compensator is slid into position. Providing a sleeve **140** over some or all of expansion/contraction section **106** may assist the expansion compensator being placed in position. In addition, when axially loaded, expansion/contraction section **106** of expansion compensator **100** may tend to deflect laterally instead of compress. Sleeve **140** may overlie some or all of expansion compensator **100** so as to inhibit and, preferably, prevent, lateral deflection under axial loading. In such a case, the inner diameter of sleeve **140** is preferably proximate that of the outer diameter of expansion/contraction section **106**.

In some embodiments, one or both ends of sleeve **140** may have one or more end surfaces **146** that generally face towards the connector at its respective end of expansion compensator **100**. In the example illustrated in FIG. **5**A, end surface **146***a* faces inwardly-facing surface **131***a* of connector **130***a*, and end surface **146***b* faces inwardly-facing surface **131***b* of connector **130***b*. While in the illustrated embodiments, a number of discontinuous end surfaces **146** extend around sleeve **140**, it will be appreciated that in variant embodiments one or more continuous end surfaces **146** may be provided at one or both ends of sleeve **140**.

Sleeve **140** may have one or more tabs **144** or other engagement means to retain it in a preset axial position about expansion compensator **100**. The engagement means permit sleeve **140** to be retained in position while still allowing expansion compensator **100** to expand and contract. Accordingly, for example, tabs **144** may be positioned axially outwardly from the axially opposed ends of expansion/contraction section **106** so as to permit expansion/contraction section **106** to expand and contract its entire design distance without restriction. Accordingly, tabs **144** may be spaced sufficiently from the last ridge of expansion/contraction section **106** (i.e. the ridge closest to the connector) such that, when fully expanded the ridge may at most abut tab **144**.

Each tab **144** may have one or more surfaces that generally face towards the connector at its respective end of expansion compensator **100**. In the example illustrated in FIG. **5**A, surface **148***a* faces inwardly-facing surface **131***a* of connector **130***a*, and surface **148***b* faces inwardly-facing surface **131***b* of connector **130***b*.

Sleeve **140** may also have one or more viewing ports **142** to allow for visual inspection of the outer surface **112** of metal conduit **110** in the expansion/contraction section **106**. FIG. **5**B illustrates an example sleeve **140** without viewing ports **142**.

Connectors **130***a,b* may be configured or adapted for coupling expansion compensator **100** to other components of a piping system. For example, connectors **130***a,b* may comprise exterior and/or interior surface features (e.g. threads, grooves, ridges, tabs), and may be dimensioned to receive (and/or be received within) a number of piping system components, such as pipes, fittings, valves, and the like. Also, while connectors **130***a,b* in the illustrated embodiments are substantially similar to each other, it will be appreciated that in alternative embodiments different connectors (e.g. for coupling to different sizes and/or types of components) may be provided on opposite ends of the same expansion compensator.

The apparatus exemplified uses an insertion fit, i.e., one end of one part of a piping system is inserted into an open end of another part of the piping system. For example, connector **130***a,b* may be dimensioned to receive first and second pipe ends inserted into first end **102** and second end **104**, respectively, of expansion compensator **100**. Connector **130** may be configured such that an end of a pipe may be inserted only up to a predetermined distance into connector **130**. This may assist in aligning one or more features (e.g. injection passages, grooves) of the connector and/or the pipe end with each other. Therefore, a stop member may be provided inside connector **130**. For example, as exemplified in FIG. **3**B, in some embodiments one or both connectors **130***a,b* may comprise an interior ridge **138** that provides an abutment surface against which a pipe end inserted into the respective connector **130***a,b* will abut when inserted a predetermined distance, to assist in coupling expansion compensator **100** to a pipe end, as shown in FIG. **4**. It will be appreciated that interior ridge **138** may have a height that is similar to or the same as the thickness of the pipe inserted into end **104**. Accordingly, the cross sectional area of flow through the pipe and the end of the expansion compensator is generally the same.

FIG. **2**D exemplifies a cross section view of expansion compensator **100** coupled to pipe ends **10***a,b*. Expansion/contraction section **106** allows for the axial length of expansion compensator **100** to vary in response to an axial force (either compressive or tensile) applied by pipe end **10***a* and/or **10***b*. For example, if thermal expansion of one or both of the pipes **10** causes pipe ends **10***a,b* to attempt to move towards each other, the pipe ends will exert a compressive force along the longitudinal axis of expansion compensator **100**. Such a compressive force may be exerted (or imposed) on expansion compensator **100** by a piping system in response to water having a temperature of from about 55° C. to about 85° C. flowing through the piping system. In response to such an applied force, expansion/contraction section **106** may contract in the axial direction, reducing the axial length of expansion compensator **100**. The amount of contraction of expansion compensator **100** will depend on the amount of the applied compressive force, and the overall axial stiffness of expansion compensator **100**. Also, if the axial stiffness of the elongate metal conduit is greater than the stiffness of the inner plastic liner, a greater portion of the applied compressive force will be borne (e.g. absorbed) by metal conduit **110** while expansion compensator **100** is compressed, and the stress on plastic liner **120** may accordingly be reduced.

As another example, if thermal contraction of one or both of the pipes **10** causes pipe ends **10***a,b* to attempt to move away from each other, the pipe ends may exert a tensile force along the longitudinal axis of expansion compensator **100**. In response to such an applied force, expansion/contraction section **106** may expand in the axial direction, increasing the axial length of expansion compensator **100**. Again, the amount of expansion of expansion compensator **100** will depend on the amount of the applied tensile force and the axial stiffness of expansion compensator **100**. Also, if the axial stiffness of the elongate metal conduit is greater than the stiffness of the inner plastic liner, a greater portion of the applied tensile force will be borne by metal conduit **110** while expansion compensator **100** is expanded, and the stress on plastic liner **120** may accordingly be reduced.

It will be appreciated that the overall stiffness of expansion compensator **100** may be selected based on the forces expected to be imposed by a piping system into which it is installed, so as to reduce the stress in the piping system components. For example, an expansion compensator **100** with a relatively lower overall stiffness may compress or expand more easily in response to an applied force than an expansion compensator **100** with a relatively higher overall stiffness. Providing a more pliant expansion compensator **100** may allow greater axial deformation (e.g. expansion or contraction) of piping system components in response to expected thermal changes, which may reduce the internal stress in these components.

It will also be appreciated that the overall stiffness of expansion compensator **100** may be selected based on the expected operating conditions once the expansion compensator has been installed in a piping system (e.g. the expected compressive and tensile loads to be exerted (or imposed) on expansion compensator **100** due to thermal expansion or contraction of components of the piping system). However, expansion compensator **100** may also be subject to compressive and/or tensile loads during its installation in a piping system.

For example, the weight of portions of a piping system installed above an expansion compensator may partially or fully compress the expansion/contraction section of the expansion compensator during installation. Therefore, when a hot fluid flows through the piping system during use, the extent to which the expansion compensator may compress to absorb the expansion of the piping system due to heating by the hot fluid is limited since the expansion compensator was installed in a compressed state. A visual inspection of the installed piping system may not reveal that the expansion/contraction section is partially compressed.

Alternatively, or in addition, when coupling an end of expansion compensator **100** to the piping system using an insertion fit, an installer may not be aware of (or may not respect) a maximum design load for expansion compensator **100**, and may apply higher forces to the expansion compensator. These higher forces may be applied intermittently (e.g. using a hammer or other striking tool) or continuously. The application of loads in excess of a maximum rated load may damage expansion compensator **100**.

The possible damage to expansion compensator **100** by the imposition of excessive loads during installation may present a number of challenges. For example, the loads imposed on expansion compensator **100** during installation loads may be difficult (if not effectively impossible) to quantify in advance. Also, communicating the maximum design load of expansion compensator **100** to an installer may be challenging. Also, even if an installer is aware of the maximum design load, an installer may inadvertently—or intentionally—exceed the maximum design load during installation.

In particular, it may be challenging to install expansion compensator **100** in a vertical section of a piping system (e.g. a hot water riser of a residential or commercial building) without subjecting expansion compensator **100** to compressive axial loads in excess of a maximum rated load for expansion compensator **100**.

As another challenge, damage to expansion compensator **100** during installation may not be apparent to a visual (or other) inspection of the installed expansion compensator **100**. For example, the application of excessive installation loads may crack or otherwise damage inner plastic liner **120** without damaging metal conduit **110**, and it may be impractical to inspect inner plastic liner **120**—visually or otherwise—once expansion compensator **100** has been installed in a piping system.

FIGS. **1**A to **2**D exemplify methods and apparatus for installing expansion compensator **100**. In order to prevent damage to expansion compensator **100** during installation and/or installation of an expansion compensator **100** in a compressed state, expansion compensator **100** may be provided with an installation guard prior to or during installation. Once the expansion compensator has been coupled to the piping system, the installation guard may be removed. In general, the method includes coupling an expansion compensator having at least one installation guard to a piping system, and once the expansion compensator is coupled to the piping system, adjusting the installation guard to permit axial compression of the expansion/contraction section during operation of the piping system. It will be appreciated that, in order to inhibit installation of an expansion compensator **100** in a compressed state, the guard may be installed after one end of expansion compensator **100** is connected to a piping system. However, it is preferred that the guard be applied prior to expansion compensator **100** being installed.

FIGS. **1**A-C illustrate an expansion compensator **100** and an installation guard, referred to generally as **200**, which may be used to inhibit axial compression of the expansion/contraction section during installation. It will be appreciated that, in variant embodiments, installation guard **200** may comprise more or fewer components.

As exemplified in FIG. **1**A, installation guard **200** comprises first and second installation guard portions **210***a,b* positioned about (i.e. exterior to) expansion/contraction section **106** of expansion compensator **100**. As shown in FIG. **1**B, installation guard portions **210***a,b* may be dimensioned so that when installation guard is mounted to expansion compensator **100**, a first end **202***a,b* of each installation guard portion **210***a,b* abuts connector **130***a* and a second end **204***a,b* of each installation guard portion **210***a,b* abuts connector **130***b*.

More specifically, a first end **202***a* of installation guard portion **210***a* abuts an inwardly facing surface **131***a* of connector **130***a*, and a second end **204***a* of installation guard portion **210***a* abuts an inwardly facing surface **131***b* of connector **130***b*. Similarly, a first end **202***b* of installation guard portion **210***b* abuts inwardly facing surface **131***a* of connector **130***a*, and a second end **204***b* of installation guard portion **210***b* abuts inwardly facing surface **131***b* of connector **130***b*.

In such an arrangement, an axial compressive load applied to first and second ends **102**,**104** of expansion compensator **100** may be partially, substantially, or preferably completely, borne by connectors **130***a,b*, and installation guard **200**, rather than by expansion/contraction section **106**. By bearing a partial, substantial, or complete portion of a compressive load applied to expansion compensator **100**, installation guard **200** may inhibit (or prevent) axial compression or excessive axial compression of the expansion/contraction section **106** during installation.

In the embodiment illustrated in FIGS. **1**A-**1**C, installation guard portions **210***a,b* are dimensioned such that when installation guard **200** is positioned about expansion compensator **100**, longitudinal edges **206***a,b* of installation guard portions **210***a,b* are brought into abutment (or near abutment) with each other. It will be appreciated that other geometries may be used, such as interlocking tabs and recesses.

Installation guard **200** may be mounted to expansion compensator **100** using any suitable means. For example, as illustrated in FIG. **10**, once installation guard portions **210***a,b* have been positioned about expansion compensator **100**, they may be secured to each other and/or to expansion compensator **100** using tape **230**. In such an embodiment, the installation guard portions **210***a,b* may be removed from expansion compensator **100** by removing, cutting, or otherwise compromising tape **230**, and then removing installation guard portions **210***a,b* from expansion compensator **100**. It will be appreciated that, alternatively or additionally, any suitable tape, adhesive, and/or mechanical coupling or fasteners, e.g., an adhesive applied to one or both installation guard portions **210***a,b*, one or more clamps, straps or the like applied around the exterior of gourd **200** or the like, may be used to mount installation guard **200** to expansion compensator **100**.

In the exemplified embodiment of FIG. **1**A, guard **200** overlies sleeve **140**. However, it will be appreciated that installation guard **200** may be used to inhibit (or prevent) axial compression of an expansion compensator **100** that is not provided with sleeve **140**. Alternatively, installation guard **200** may be configured to co-operate with sleeve **140** to inhibit (or prevent) axial compression during installation.

FIGS. **2**A-**2**D exemplifies an expansion compensator **100** with an embodiment of an installation guard that co-operates with sleeve **140** during installation in a piping system. It will be appreciated that while expansion compensator **100** is shown in a somewhat horizontal orientation, installation guard **200** may be used to inhibit (or prevent) axial compression of an expansion compensator **100** installed in a vertical section of a piping system (e.g. a hot water riser of a residential or commercial building), or in any other orientation.

As exemplified in FIG. **2**A, this installation guard comprises a first installation guard portion **220***a* positioned about (i.e. exterior to) expansion compensator **100** between connector **130***a* and sleeve **140**, and a second installation guard portion **220***b* positioned about (i.e. exterior to) expansion compensator **100** between connector **130***b* and sleeve **140**.

More specifically, a first end **222***a* of first installation guard portion **220***a* abuts inwardly-facing surface **131***a* of connector **130***a*, and a second end **224***a* of first installation guard portion **220***a* abuts end surface **146***a* of sleeve **140**. Similarly, a first end **222***b* of second installation guard portion **220***b* abuts inwardly-facing surface **131***b* of connector **130***b*, and a second end **224***b* of second installation guard portion **220***b* abuts end surface **146***b* of sleeve **140**. It will be appreciated that in variant embodiments of installation guard portions **220***a,b*, second ends **224***a,b* may alternatively, or additionally, abut one or more surfaces **148***a,b*, on tabs **144** of sleeve **140**.

In such an arrangement, an axial compressive load applied to first and second ends **102**,**104** of expansion compensator **100** may be partially, substantially, or preferably completely borne by connectors **130***a,b*, installation guard portions **220***a,b*, and sleeve **140**, rather than by expansion/contraction section **106**. By bearing a partial, substantial, or complete portion of a compressive load applied to expansion compensator **100**, installation guard portions **220***a,b* and sleeve **140** may inhibit (or prevent) axial compression, or excessive axial compression, of the expansion/contraction section **106** during installation.

Installation guard portions **220***a,b* may each comprise two or more separate portions (e.g. each may comprise a pair of semi-circular components, similar to installation guard portions **210***a,b* in FIGS. **1**A-C).

Installation guard portions **220***a,b* may be mounted to expansion compensator **100** using any suitable means. For example, where installation guard portions **220***a,b* may each comprise two or more separate portions, once these separate portions have been positioned about expansion compensator **100**, they may be secured to each other and/or to expansion compensator **100** using a tape, another adhesive, and/or using a mechanical coupling or fasteners discussed herein. In such an embodiment, the installation guard portions **220***a,b* may be removed from expansion compensator **100** by removing, cutting, or otherwise compromising the securing means, and then removing installation guard portions **220***a,b* from expansion compensator **100**.

It will be appreciated that any suitable geometry may be used for the installation guard. For example, installation guard **220** may comprise a unitary tubular body, and be mounted to expansion compensator **100** during manufacture of expansion compensator **100** (e.g. before connectors **130** are provided on the ends of expansion compensator **100**). Installation guard **200** may comprise a single layer of material that is wrapped around (e.g. spirally wound around) expansion compensation **100** and secured in position, such as by gluing one end in overlapping relationship to another portion of the installation guard. Alternatively, installation guard may comprise one or more discrete longitudinally extending members that may be spaced around the expansion compensator.

In some embodiments, rather than being removed (either partially or completely), installation guard **200** may be configured so that it may be deformed to enable compression of the expansion/contraction section during use of the piping system. For example, material may be removed from installation guard **200** so that, while still in abutment with connectors **130** (and in the case of installation guard portions **220**, in abutment with sleeve **140**), the installation guard has an axial stiffness that is less than the axial stiffness of expansion/contraction section **106**. Alternatively, or additionally, installation guard **200** may be deformed such that the ends of the installation guard portions are no longer in abutment with connectors **130** (and/or sleeve **140**). If the installation guard is no longer in abutment with connectors **130**, it may be inoperable to inhibit axial compression of the expansion/contraction section. For example, the installation guard portions may be telescopically configured or one or more layers may be removed from installation guard to weaken the installation guard and enable it to be compressed during use of the expansion compensator without significantly impacting the performance of the expansion compensator.

It will also be appreciated that expansion compensator **100** may itself expand or contract due to thermal expansion or contraction prior to its installation in a piping system. For example, expansion compensator **100** may be designed for installation at room temperature (e.g., 20° C.). For example, for a pipe installed at about 20° C. and used to convey hot water in a residential building (which is typically at a temperature of 70° C. to 83° C.), the degree of thermal expansion will be based on a temperature difference of approximately 50° C. to 63° C. An expansion compensator **100** may be designed to absorb the stresses expected on it due to such a degree of expansion (e.g., it may be designed to compress a sufficient amount to remove excessing compression due to such expansion of the piping system due to such a temperature differential).

However, if the same piping system is installed at about 0° C., the degree of thermal expansion due to conveying water at a temperature of 70° C. to 83° C. will be based on a temperature difference of approximately 70° C. to 83° C. This will impose a greater expansion stress on an expansion compensator **100**. In addition, if an expansion compensator **100** is installed at say 0° C., then it will be appreciated that the expansion compensator will itself compress (it will have a shorter length at 0° C. than at room temperature). If the expansion compensator is allowed to thermally contract when installed in cold weather conditions, then the piping system will exert a first force on the expansion compensator when the piping system is exposed to room temperature (e.g., a house is completed and heated to room temperature). When the piping system is subsequently used to convey a heated fluid (e.g., residential hot water), then the piping system will exert a second force on the expansion compensator. This can be considered the design compression force or expansion stress for which the expansion compensator was designed. However, the degree to which the expansion compensator can compress to absorb the second force is limited by two factors. First, due to its installation in cold weather conditions, the expansion/contraction section may be partially compressed. Secondly, due to the first force, the expansion/compression section has already been compressed a particular amount. Therefore, the expansion/compression section may not be able to compress a sufficient amount to absorb a predetermined amount of the second force.

Accordingly, a thermal compression guard may be provided on expansion compensator **100**. The thermal compression guard acts to inhibit and, preferably, prevent thermal contraction of all or a portion of expansion compensation **100** when expansion compensator **100** is installed in cold weather conditions. Accordingly, the thermal compression guard may be a member provided on expansion compensator **100** to limit contraction of all of a portion of the expansion/contraction section when it is exposed to temperatures below, e.g., room temperature (such as a temperature less than 20° C., less than 15° C., less than 10° C. or less than 5° C.).

In some embodiments, for example, the thermal compression guard may be a separate member from the installation guard. For example, the thermal compression guard may be a sleeve that inhibits or prevents all or a portion of expansion compensator **100**, such as all or a portion of the expansion/contraction section, from contracting at low temperatures. An example may be a sleeve such as sleeve **140** that engages in grooves of the expansion/contraction section and inhibits or prevents the expansion/contraction section from contracting at low temperatures. The installation guard may be a sleeve (e.g., a sleeve formed from sleeve portions **210***a,b*) that is positioned interior or exterior to sleeve **140** so as to inhibit or prevent compression of all or a portion of expansion compensator **100**, such as all or a portion of the expansion/contraction section, due to the weight of the piping system installed above the expansion compensation and imposed on the expansion compensator during installation.

In some embodiments, for example, the thermal compression guard may be the installation guard. Accordingly the same member may be designed to both inhibit or prevent all or a portion of expansion compensator **100**, such as all or a portion of the expansion/contraction section, contracting due the thermal contraction and loads imposed by the piping system during installation.

It will be appreciated that installation guard **200** may be mounted to expansion compensator **100** during manufacture of expansion compensator **100**, before delivering expansion compensator **100** to a site where it will be installed to a piping system, or at the site but before coupling expansion compensator **100** to the piping system.

Preferably, installation guard **200** (and/or sleeve **140**) has a lower coefficient of thermal expansion than expansion compensator **100**, when measured along the longitudinal axis. Also, installation guard **200** is preferably mounted to the expansion compensator when the expansion compensator is at a predetermined temperature (e.g. at about 20° C.). Thus, when the expansion compensator and installation guard are subsequently cooled, installation guard **200** may inhibit (or prevent) axial compression or excessive axial compression of the expansion/contraction section **106** due to thermal contraction. In this way, installation guard **200** inhibits or prevents expansion compensator **100** from being installed in a compressed or partially compressed state, regardless of the temperature at which it is installed.

For example, installation guard **200** may be made from a material that has a low coefficient of thermal expansion relative to the coefficient of thermal expansion of inner plastic liner **120**, metal conduit **110**, and/or the overall coefficient of thermal expansion of expansion/contraction section **106**. Alternatively, or additionally, the geometry of installation guard **200** may be selected to limit the amount of axial contraction due to cooling.

Preferably, installation guard **200** is made from a relatively low cost material that can provide an installation guard **200** with sufficient stiffness and/or rigidity, such as cellulose or one or more other suitable biodegradable materials, although it will be appreciated that other materials may be used. For example, installation guard may be made for cardboard, corrugated cardboard, plastic or metal.

Returning to FIG. **2**A, expansion compensator **100**—with installation guard portions **220***a,b* mounted to expansion compensator—is shown disposed between and aligned with pipe ends **10***a,b*. More specifically, connector **130***a* is aligned with pipe end **10***a*, and connector **130***b* is aligned with pipe end **10***b*. In the illustrated embodiment, connectors **130***a,b* are dimensioned to receive therein, respectively, pipe ends **10***a,b*. FIG. **2**B shows expansion compensator **100** once it has been coupled to pipe ends **10***a,b*. It will be appreciated that the ends of connectors **130***a,b* may be configured to be connected to a pipe end **10***a,b* by any means known in the piping arts.

During the coupling of expansion compensator **100** to pipe ends **10***a,b*, installation guard portions **220***a,b* and sleeve **140** cooperate to inhibit or prevent a compressive load applied to first and/or second ends **102**,**104** of expansion compensator **100** (e.g. to connectors **130***a,b* from the weight of the piping system above expansion compensator **100**) from being borne by expansion/contraction section **106**. For the embodiment of installation guard **200** shown in FIGS. **1**A-**1**C, installation guard portions **210***a,b* inhibit or prevent a compressive load applied to first and second ends **102**,**104** of expansion compensator **100** from being borne by expansion/contraction section **106**.

It will be appreciated that while the example embodiments of installation guard **200** illustrated in FIGS. **1**B and **2**A are operable to inhibit axial compression of the expansion/contraction section through abutment with connectors **130***a,b*, this need not be the case. For example, one or more flanges or other surface features may be provided on outer surface **112** of metal conduit **110** on one or both sides of an expansion/contraction section of expansion compensator **100** (e.g. between connector **130** and expansion/contraction section **106**), and an installation guard may be configured to abut or otherwise engage with these flanges or surface features and/or connectors **130** to inhibit axial compression of the expansion/contraction section.

Alternatively, or additionally, an installation guard may be configured to abut or engage with one or both of the last ridges of expansion/contraction section **106** (i.e. the ridges closest to the connectors) to inhibit axial compression of the expansion/contraction section.

If the axial stiffness of the installation guard is greater than the stiffness of the unguarded expansion compensator (i.e. the stiffness of expansion/contraction section **106**), a greater portion (preferably a substantial portion, and most preferably all or substantially all) of an axial force applied to expansion compensator **100** will be borne (e.g. absorbed) by the installation guard, while expansion/contraction section **106** will bear a smaller portion (preferably a significantly smaller portion and more preferably none) of the applied axial force. It will also be appreciated that if the axial stiffness is of the installation guard is sufficient to resist a force greater than the expected compressive force to be applied during installation without significant axial displacement (i.e. compression), then expansion/contraction section **106** will not be compressed during installation. In this way, installation guard **200** inhibits axial compression of the expansion/contraction section, which may prevent damage to expansion compensator **100** during installation.

FIG. **2**C shows expansion compensator **100** once it has been coupled to pipe ends **10***a,b* and the installation guard has been removed. Without the installation guard portions **210***a,b*, expansion/contraction section **106** allows for the axial length of expansion compensator **100** to vary in response to an axial force (either compressive or tensile) applied by pipe end **10***a* and/or **10***b*, as discussed above with reference to FIG. **2**D.

It will be appreciated that, in some embodiments, which may be used by itself or with any other embodiment disclosed herein, an expansion compensator which has a greater ability to contract and absorb compressive forces may be desired. One option is to provide an expansion compensator with a longer expansion/contraction section and/or a greater spacing may be provided between the ridges of the expansion/contraction section. Alternately or in addition, the expansion compensator may be pre-tensioned. For example, prior to the installation of an installation guard and/or a thermal compression guard, the expansion compensator may be stretched. For example, each end of the expansion compensator may be secured in a clamp and pulled outwardly so as to stretch the expansion/contraction section. Once the expansion/contraction section has been stretched, the installation guard and/or a thermal compression guard may be installed so as to maintain the expansion/contraction section in a stretched condition. An advantage of this embodiment is that the expansion compensator may contract a greater amount when a compressive load is applied due to the thermal expansion of pipes attached thereto. This embodiment may be used when, for example, an expansion compensator is to be installed between longer runs of pipe (e.g., the height in the floor of a building may be 12-20 feet or more).

As used herein, the wording "and/or" is intended to represent an inclusive-or. That is, "X and/or Y" is intended to mean X or Y or both, for example. As a further example, "X, Y, and/or Z" is intended to mean X or Y or Z or any combination thereof.

While the above description describes features of example embodiments, it will be appreciated that some features and/or functions of the described embodiments are susceptible to modification without departing from the spirit and principles of operation of the described embodiments. For example, the various characteristics which are described by means of the represented embodiments or examples may be selectively combined with each other. Accordingly, what has been described above is intended to be illustrative of the claimed concept and non-limiting. It will be understood by persons skilled in the art that other variants and modifications may be made without departing from the scope of the invention as defined in the claims appended hereto. The scope of the claims should not be limited by the preferred embodiments and examples, but should be given the broadest interpretation consistent with the description as a whole.

The invention claimed is:

1. An expansion compensator and an installation guard, the expansion compensator connectable in a piping system:

(a) the expansion compensator comprising:

(i) an elongate conduit having first and second longitudinally spaced apart ends, an inner surface, an outer surface, a longitudinally extending expansion/contraction section and an interior volume extending from the first end to the second end;

(ii) a first connector provided at the first end of the elongate conduit, the first connector having an opening in fluid communication with the interior volume;

(iii) a first inwardly facing surface spaced laterally outwardly from a lateral outer extent of the expansion/contraction section and facing longitudinally inwardly towards the second end;

(iv) a second connector provided at the second end of the elongate conduit, the second connector having an opening in fluid communication with the interior volume; and

(v) a second inwardly facing surface spaced laterally outwardly from a lateral outer extent of the expansion/contraction section and facing longitudinally inwardly towards the first end;

and,

(b) the installation guard positionable around an exterior of the expansion/contraction section, the installation guard comprising a first end and a longitudinally spaced apart second end wherein, when installed, the first end of the installation guard is positioned to abut the first inwardly facing surface of the first connector and the second axially spaced apart end of the installation guard is positioned to abut the second inwardly facing surface of the second connector whereby when installed, the installation guard inhibits longitudinal compression of the expansion/contraction section during installation while permitting longitudinal expansion of the expansion/contraction section when the installation guard is installed on the expansion compensator,

wherein the installation guard comprises at least two axially extending elongate members which combined circumferentially extend around the expansion compensator while each elongate member individually circumferentially extends only part way around the expansion compensator.

2. The expansion compensator and the installation guard of claim **1**, wherein the installation guard is removably mounted to the expansion compensator.

3. The expansion compensator and the installation guard of claim **1**, wherein the installation guard is configured to be deformed following installation to enable compression of the expansion/contraction section during use of the piping system.

4. The expansion compensator and the installation guard of claim **3**, wherein at least one of the at least two elongate members is removable from the expansion/contraction section.

5. The expansion compensator and the installation guard of claim **4**, wherein the at least two elongate members are discrete installation guard portions.

6. The expansion compensator and the installation guard of claim **5**, wherein the at least two elongate members are removably secured to each other.

7. The expansion compensator and the installation guard of claim **6**, wherein the at least two elongate members are removably secured to each other using tape.

8. The expansion compensator and the installation guard of claim **1**, wherein the installation guard is made of cellulose.

9. The expansion compensator and the installation guard of to claim **1**, wherein the expansion/contraction section has a first coefficient of thermal expansion along a longitudinal axis, the installation guard has a second, lower coefficient of thermal expansion along the longitudinal axis and the installation guard is operable to inhibit axial compression of the expansion/contraction section due to thermal contraction of the expansion compensator.

10. The expansion compensator and the installation guard of claim **9**, wherein the installation guard also comprises a thermal compression guard.

11. The expansion compensator and the installation guard of claim **1**, wherein a single first inwardly facing surface and a single second inwardly facing surface are provided whereby, when the installation guard is installed, the expansion/contraction section is inhibited from inward compression from only a single position.

* * * * *