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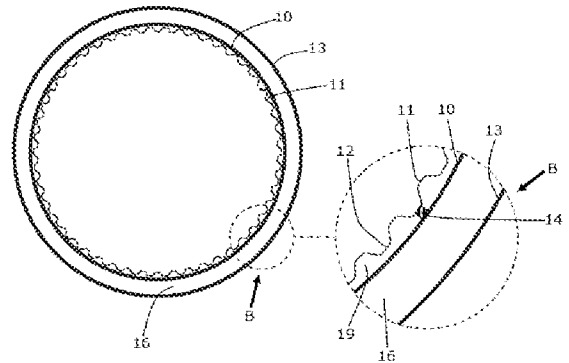
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(54) Title **Improved cryogenic storage tank**  
(57) Abstract

The present invention disclose an improved cryogenic storage tank with an integrated heat exchanger cooling cryogenic fluids being stored inside the tank. The heat exchanger is in fluid communication with an external cooling machine.



Improved cryogenic storage tank

## FIELD OF THE INVENTION

- 5 The present invention relates to an improved cryogenic handling system comprising a cryogenic storage tank integrated with an internal cooling facility.

## BACKGROUND OF THE INVENTION

10 Hydrogen (H<sub>2</sub>) and Liquid Natural Gas (LNG) are normally stored in a liquified state since the volume is significantly less when in a liquid state compared to the gas state. However, there are some different physical properties between LH<sub>2</sub> and LNG.

The density of LH<sub>2</sub> decreases significantly when the pressure and temperature increases. For example, if the pressure is about 10 barg and the temperature increases 10 °C the density is about 50 kg per m<sup>3</sup>. If LH<sub>2</sub> is stored at a temperature about -253 °C and at atmospheric pressure the density is about 71kg per m<sup>3</sup>. This implies that the effective storage capacity of LH<sub>2</sub> increases with about 40% if LH<sub>2</sub> is stored at atmospheric pressure at -253 °C compared with a situation where the pressure is 10 barg and the temperature increases, for example with 10 °C.

20 Therefore, utilizing full storage tank capacity, or transport tank capacity, for LH<sub>2</sub> may be a challenge.

A common tank design used for storage and transport of LH<sub>2</sub> comprises two layers of steel plates with vacuum insulation between the steel plate layers. There is also some insulation, for example heat radiation reflecting materials inside the two steel plate layers. Usually these tanks are shaped as a cylinder or are spherically shaped. The principal design of such tanks resembles the commonly known thermos. Despite the good insulation properties of such tanks there is a leakage of heat into such tanks, which results in an increase of pressure inside these tanks, which for example reduces available storage volume for LH<sub>2</sub>.

35 When LNG is stored in such tanks the same problem of heat leakage results in a pressure increase. Therefore, it is necessary to release some gas or use some of the cryogenic fluid to avoid buildup of pressures inside tanks above a level which may harm the tank.

The challenge with LH<sub>2</sub> is that the boiling point at atmospheric pressure is about -253 °C. Typically the holding time or storage time for LH<sub>2</sub> in for example vacuum insulated tanks is about 15 days before the pressure reaches a dangerous level. For LNG, which has a boiling point around - 163 °C, the holding or storage time is typically 25 days. The typical pressure a LH<sub>2</sub> tank should be able to withstand is around 10 barg.

Release of excessive pressure in tanks is normally done by releasing some gas or fluid to the surroundings. If the storage time is over a longer time period, for example for LH<sub>2</sub> in a vacuum insulated tank, the available content of LH<sub>2</sub> decreases after each consecutive 15 days periods due to the necessity of releasing some of the stored content at least after 15 days. Some long-term storage facilities for LNG is known to capture released gases from tanks and converting the gases back to a liquid state and insert the liquified gasses back into the storage tanks.

Another phenomenon with cryogenic stored fluids is that a layering of stored liquified fluids may happen. Especially in large open LNG storage tanks. A vertical liquified LNG fluid column inside a tank will sometimes have different density at the bottom of the column than at the top layer of the liquified column due to temperature influx and the static liquid pressure, while LNG at the top evaporates at near ambient pressure and will be kept cold near boiling point. Then a phenomenon denoted roll-over may occur when heavier LNG fluid layers at the top of the LNG fluid column changes place with lighter LNG fluid layers at the bottom of the LNG fluid column. This may happen abruptly inducing mechanical stress in the tank which may damage the construction.

A more detailed description of roll-over problems can be found in the link [https://giiqnl.org/sites/default/files/PUBLIC\\_AREA/Publications/rollover\\_in\\_lng\\_storage\\_tanks\\_public\\_document\\_low-res.pdf](https://giiqnl.org/sites/default/files/PUBLIC_AREA/Publications/rollover_in_lng_storage_tanks_public_document_low-res.pdf)

From a chemical point of view LH<sub>2</sub> is a uniform commodity in contrast to LNG. However, LH<sub>2</sub> can have different electron spin dependent on pressure and temperature, which respectively is denoted orthohydrogen and parahydrogen. Parahydrogen has the lowest energy level. In liquid form this implies that when the LH<sub>2</sub> is stored at lower temperatures the LH<sub>2</sub> is mainly parahydrogen. If some heating occurs (leakage trough the insulation for example), a transfer to orthohydrogen

occurs. This transfer to orthohydrogen develops some heat adding heat to the heat transferred through the insulation.

5 An aspect of the present invention is to preserve a specific quality of cryogenic commodities obtained at a production site until delivery at a consumer site. At the production site the cryogenic commodity may be produced according to a specific specification ordered by a consumer and should be deliverable with the same specified quality independent of how long a commodity is stored or how it is transported and delivered to a consumer.

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In prior art it is known several examples of LNG storage tanks. However, utilizing known LNG tanks for storage of hydrogen may not be a straightforward possibility. As indicated above there are also some common problems shared between the two types of cryogenic fluids like limited holding times.

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With respect to LH<sub>2</sub> storage tanks a well-known example is a LH<sub>2</sub> storage tank designed and used by NASA to store and supply hydrogen-based rocket fuel. The article "Integrated Refrigeration and Storage for Advanced Liquid Hydrogen Operations" by Adam Swanger et.al. disclosed January 2017 at the conference "International Cryocooler Conference" in January 2017, volume 19, discloses an example of a design denoted IRAS. In experiments conducted by NASA a spherical shaped cryogenic tank with a coiled tube with a circulating cooling liquid was inserted into the spherical shaped cryogenic tank. A holding time of about 11 months was obtained for LH<sub>2</sub> in this tank.

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The problem with for example roll-over has not been addresses by the IRAS project since a spherical shaped tank has less problems with roll-over due to the geometry of the tank.

30 The growing interest in using hydrogen as a fuel, for example in fuel cells for cars, or as a fuel cells for ship propulsion etc. is due to the beneficial aspect of the rest product from hydrogen when used in fuel cells etc., which is pure water. To be able to utilize hydrogen on a larger scale in society this will probably require much longer holding times than what is possible today. Also, storage, transport and distribution systems that can keep a specified quality intact of hydrogen commodities is probably  
35 necessary.

Therefore, it is a need of an improved internal cooling of cryogenic fluids stored in tanks, and especially a colling system providing an almost same temperature in a volume of stored cryogenic fluids in a vertical and horizontal direction of the storage tank.

#### OBJECT OF THE INVENTION

It is a further object of the present invention to provide an alternative to the prior art.

10 In particular, it may be seen as an object of the present invention to provide a cryogenic storage tank with a cooling system integrated with or arranged inside tank walls of the cryogenic storage tank.

#### SUMMARY OF THE INVENTION

Thus, the above described object and several other objects are intended to be  
 15 obtained in a first aspect of the invention by providing a cryogenic storage tank, wherein a heat exchanger is attached or integrated with at least a part of an inner wall of the cryogenic storage tank.

The invention is particularly, but not exclusively, advantageous for obtaining a cryogenic storage tank comprising a cooling heat exchanger having a defined width and  
 20 length,

- wherein the heat exchanger is integrated with an inner tank wall of the storage space of the cryogenic storage tank, wherein a surface area provided by the defined width and length of the heat exchanger is in  
 25 thermal contact with cryogenic fluid stored in the tank.

The invention is further particularly, but not exclusively, advantageous for obtaining a method of mounting a heat exchanger inside a cryogenic tank comprising steps of:

- mounting at least one vent onto a surface of at least one thin steel plate,
- 30 - spotwelding the at least one thin steel plate with the at least one mounted vent onto an inner surface of the cryogenic tank,
- the spot welding is done in a regular pattern on the at least one thin steel plate,

- attaching a pipe to the at least one vent and apply high pressurized water into the backside of the at least one thin steel plate thereby creating a plurality of protruding corrugations in between the regular pattern of the spot welding,
- 5 - removing the at least one attached vent and close the opening left after removal of the at least one vent, and
- welding the circumference of the at least one thin steel plate creating a closed compartment between the at least one thin steel plate and the inner surface of the cryogenic storage tank.

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Respective aspects of the present invention may each be combined with any of the other aspects. These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described herein.

## 15 DESCRIPTION OF THE FIGURES

The cryogenic storage tank according to the present invention will now be described in more detail with reference to the accompanying figures. The attached figures illustrates an example of embodiment of the present invention and is not to be construed as being limiting to other possible embodiments falling within the scope of  
20 the attached claim set.

Figure 1 illustrates an example of a prior art cryogenic storage tank

Figure 2A illustrates an aspect of the present invention.

Figure 2B illustrates an example of embodiment of the present invention.

Figure 3 illustrates further details of the example of embodiment illustrated in Figure  
25 2B.

Figure 4 illustrates a further aspect of the present invention.

Figure 5 illustrates another example of embodiment of the present invention.

Figure 6 illustrates another example of embodiment of the present invention.

Figure 7 illustrates another example of embodiment of the present invention.

## DETAILED DESCRIPTION OF AN EXAMPLE OF EMBODIMENT

Although the present invention has been described in connection with the specified embodiments, it should not be construed as being in any way limited to the presented examples. The scope of the present invention is set out by the  
5 accompanying claim set. In the context of the claims, the terms "comprising" or "comprises" do not exclude other possible elements or steps. Further, the mentioning of references such as "a" or "an" etc. should not be construed as excluding a plurality. The use of reference signs in the claims with respect to elements indicated in the figures shall also not be construed as limiting the scope of the invention.  
10 Furthermore, individual features mentioned in different claims, may possibly be advantageously combined, and the mentioning of these features in different claims does not exclude that a combination of features is not possible and advantageous.

Figure 1 illustrates an example of a prior art storage tank comprising an outer metal container with a metal wall 13 and an inner metal container with a metal wall 10.  
15 The space 16 between the outer wall 13 and the inner wall 10 is kept at vacuum. Spacer elements 15 are arranged to keep the inner and outer walls of the storage tank in a fixed position relative to each other.

Such storage tanks are also used in transport trucks as known in prior art, for example positioned horizontally.

20 According to an aspect of the present invention a control of internal temperature of a cryogenic fluid in a tank can be obtained with a heat exchanger design as illustrated in Figure 2A. A metal wall 10, which may be similar to the inner wall 10 of Figure 1 has a corrugated thin steel plate 11 arranged on a surface of the inner wall 10 facing towards the storage space of the tank, for example. The corrugated thin steel plate  
25 is point-welded 12 to the inner wall 10 in a regular pattern as illustrated in Figure 2A.

Figure 2B illustrates further details of the section B of Figure 2A. Point welding spots 14 is illustrated which leaves a space 19 between the corrugated steel plate 11 and  
30 the inner surface of the inner wall 10, which is used to circulate for example a cooling fluid. The vacuum space 16 in combination with the cooling inside the space 19 provides a possibility to control the cooling of cryogenic fluids stored inside the illustrated example of a storage tank at lower temperatures that can prolong the

holding time of cryogenic fluid. It is also within the scope of the present invention to use a distal element as part of a spot-welding point thereby providing a defined distance between the corrugated steel plate 11 and the inner tank wall 10. In this manner the volume of the space 19 and thereby the volume of the cooling fluid  
5 circulating inside the space 19.

An important aspect of this design is that heat entering the tank from surroundings outside the tank actually is stoppable at the inner wall 10 of the tank. Transport of heat from surroundings around a cryogenic tank is a known problem in prior art, and  
10 despite the best available insulation methods there will be a heat transport into the interior of the storage tank. The aspect of the present invention that a heat exchanger according to the present invention stops such external heat transfers into the storage space is in contrast to the design of the IRAS project of NASA where heat is entering into the cryogenic fluid before the cooling coil of the IRAS tank can  
15 remove any imported heat.

This aspect of the present invention contributes to an extendable holding time of stored cryogenic fluids beyond the maximum reported holding time of 11 months for the IRAS tank. In fact, it is probable that a cryogenic storage tank according to the  
20 present invention may have indefinite holding time if the cooling system is operable and maintained over time.

Figure 3 illustrates further details of how a heat exchanger according to the present invention can be mounted inside a tank. The first step is to point weld 14 a thin flat  
25 steel plate 11 onto an inner wall 10. Other techniques like melting the two steel surfaces to each other is also possible. Then a pipe is attached to at least one vent 18 onto an outer surface of the thin flat steel plate 11. A pipe 17 is then attached to the at least one vent 18 and high pressurized water 17 is applied onto the backside of the point-welded thin flat steel plate 10. Then a regular pattern with corrugations  
30 are established creating the space 19 that can be used to circulate a cooling fluid.

A plurality of thin steel plates welded together and attached in this manner defines a surface of the heat exchanger of the present invention. The size of an area of a heat exchanger according to the present invention is dependable partly on which heat  
35 transfer capacity the exchanger requires for a specific tank. It is therefore within the scope of the present invention that a heat exchanger may cover at least a part of an

inner storage tank wall, including covering up to a whole surface of an inner storage tank wall.

When welding the circumference of the respective thin steel plate(s) a closed  
5 compartment 19 between the thin steel plate(s) 11 and the inner surface of the cryogenic storage tank is created.

The heat exchanger according to the present invention can be made and mounted by  
a method as discussed above when building a new tank. It is also within the scope of  
10 the present invention that an existing tank can be modified this way by for example removing a top section for example of the tank providing access to the interior of the tank. Then a heat exchanger according to the present invention can be made and mounted inside the tank.

15 It is also within the scope of the present invention to utilize pre-corrugated thin plates as basis for the heat exchanger.

Figure 4 illustrates the possibility of adding more than one thin steel plate onto a  
wall. For example, a first thin steel plate 11a is mounted and expanded with  
20 pressurized water on an inner surface of the tank followed by point-welding a second thin steel plate 11b onto the first thin steel plate followed for example with an extra third thin steel plate 11c which in this example will be facing towards the inner storage volume of the tank. In this manner a first space 19a between the inner wall  
10 and the first thin steel plate 11a is created, and a second space 19b is created  
25 between the first thin steel plate 11a and the second thin steel plate 11b, and a third space 19c is established between the second thin steel plate 11b and the third thin steel plate 11c. In this manner, several inner spaces are provided inside the heat exchanger that may be utilized for specific purposes, for example for leakage  
detection, inlet channel for cooling fluid, outlet channel for cooling fluid, etc.

30 According to an example of embodiment of the present invention a cryogenic storage tank comprises a cooling heat exchanger having a defined width and length,

- wherein the heat exchanger is integrated with an inner tank wall of the  
35 storage space of the cryogenic storage tank, wherein a surface area of the heat exchanger provided by the defined width and length of the heat exchanger is in thermal contact with cryogenic fluid stored in the tank.

According to an example of embodiment of the present invention a method of mounting a heat exchanger inside a cryogenic tank comprises steps of:

- 5 - mounting at least one vent onto a surface of at least one thin steel plate,
- spotwelding the at least one thin steel plate with the at least one mounted vent onto an inner surface of the cryogenic tank,
- the spot welding is done in a regular pattern on the thin steel plate(s),
- attaching a pipe to the at least one vent and apply high pressurized water into the backside of the thin steel plate(s) thereby creating a plurality of protruding corrugations in between the regular pattern of the spot welding,
- 10 - removing the at least one attached vent and close the opening left after removal of the at least one vent, for example by welding, and
- welding the circumference of the thin steel plate(s) to create a closed compartment between the thin steel plate(s) and the inner surface of the cryogenic storage tank.
- 15

Further corrugated thin steel plates as discussed above can be spot-welded onto the first mounted thin steel plate and so on, for example.

20 For example, the second space 19b and the third space 19c can be used to circulate a cooling fluid, i.e. the cooling fluid is applied for example into the second space 19b from an external cooling machine while the third space 19c returns the cooling fluid back to the external cooling via an arranged tubing in communication with the third space 19c.

25 The first space 19a can for example be used to detect possible leakage of stored cryogenic fluids, for example by utilizing a gas inside the first space 19a in what is denoted a sniffer test in prior art.

30 Figure 5 illustrates another example of embodiment of the present invention. A thin steel plate 11 is corrugated and spotwelded onto a surface of an inner wall 10 facing towards a vacuum space 16 arranged between the inner wall 10 and the outer wall 13. In this example of embodiment an example of a heat exchanger according to the present invention is arranged inside the vacuum space 16.

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Figure 6 illustrates another example of a storage tank wherein a cooling machine 20 for example applies a cooling fluid into a space 19 arranged between a corrugated thin steel plate 11 and the inner wall 10 of a tank. The tubing 21a delivers 23a cooling fluid while the tubing 21b returns 23b the cooling fluid back to the cooling machine 20.

Figure 7 illustrates another example of embodiment of the present invention wherein a cooling element comprising a flat plate 10a is arranged with a corrugated thin steel plate 11 on one side of the flat plate 10a. The cooling element is mounted for example along a center line of the tank and a cooling fluid is supplied via a first pipe 21a in one end of the cooling element from an external cooling machine 20 while a second pipe 21b in an opposite end of the cooling element is returning the cooling fluid back to the cooling machine.

The effect of arranging a heat exchanger according to the present invention inside a storage tank provides an almost uniform temperature profile in a cryogenic fluid both in horizontal and vertical directions inside the cryogenic fluid. This results in an almost unlimited holding time as long as the cooling is effective.

With reference to open LNG tanks as discussed above, the roll-over problem is mitigated with examples of embodiment of the present invention.

If a connected cooling machine should stop working due to a failure or maintenance need this is not a problem. If for example a thermos type of storage tank is used when storing LH<sub>2</sub> there will be a period of 15 days before an excessive pressure buildup occurs. This is more than enough time to repair or replace a cooling machine.

In addition, approximately 40% increased storage capacity can be achieved for LH<sub>2</sub>.

Another aspect of the present invention is that the cold area of a heat exchanger according to the present invention is in contact with the inner tank wall face, either on a side face facing towards the storage space, or on a side face facing away from the storage space. This is in contrast to for example the cooling coil disclosed by NASA's IRAS project. The technical difference is that the solution of the present invention can stop any heat coming from the outside environment of the storage

tank to reach any cryogenic fluid stored inside the tank. In the NASA solution heat enters the stored cryogenic fluid (heating the fluid) before being removed by the cooling coil of NASA's solution. Therefore, the present invention is not just an alternative to the NASA storage tank. The technical difference of stopping heat from entering stored cryogenic fluids inside the storage tank provides a more stable temperature regime which may for example improve or keep the quality of a cryogenic fluid for a longer period of time. This effect is also achievable when utilizing the present invention in a spherical tank like the IRAS tank.

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- 10 The lower and more stable temperature regime achievable with embodiments of the present invention may also prevent any situation wherein heat generated by a transition from parahydrogen to orthohydrogen accelerates.

Another aspect of the present invention is that when moving for example cryogenic fluids from one tank to another, for example from a tank on a lorry to a consumer tank, the receiving tank can be at atmospheric pressure. Further, if the piping between the two tanks is provided for by a cooled pipe, the quality of the commodity is kept.

- 15
- 20 A further aspect of the present invention is that a heat exchanger according to the present invention will increase the mechanical integrity of the inner wall of a tank when a thin steel plate is spotwelded onto the inner surface of the tank.

The thermal impedance of a heat exchanger according to the present invention is a function of thermal resistance and thermal contact resistance, i.e. in the interface where the heat exchanger surface meets the cryogenic fluid in the tank. The thermal resistance is mainly related to the thickness of the corrugated steel plate 11. Thinner steel plates transfer heat much more efficient. The size of the surface area of the corrugated steel plate is much larger than for a corresponding sized steel plate which implies a larger transfer capacity of the heat exchanger. In the context of the present invention, a reference to a thin steel plate is a reference to a thickness of the steel plate providing a sufficient low thermal resistance.

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35 The thermal contact resistance is usually a function of how smooth a surface is. If there are irregularities in the surface for example, micro voids may be created

reducing the heat transfer capacity as known in prior art. It is within the scope of the present invention to utilize a heat exchanger with smooth surfaces

5 A heat exchanger according to the present invention requires a certain cooling capacity when providing for example a holding time for LH<sub>2</sub> beyond for example 15 days. There are generally two parameters that may be adapted to achieve a certain cooling capacity, which is a size of an area of the heat exchanger in thermal contact with stored cryogenic fluids and the volume or heat capacity of the cooling fluid circulating inside the heat exchanger according to the present invention. The  
10 inherent aspect of the present invention of stopping external heat transport into stored cryogenic fluids in the tank wall itself simplifies the assessment of a required cooling capacity.

15 According to an example of embodiment of the present invention, a cryogenic storage tank comprises a cooling heat exchanger having a defined width and length,

- wherein the heat exchanger is integrated with an inner tank wall (10) of the storage space of the cryogenic storage tank, wherein a surface area of the heat exchanger provided by the defined width and length of the heat  
20 exchanger is in thermal contact with cryogenic fluid stored in the tank.

Further, a heat exchanger according to the present invention may be integrated with the inner tank wall (10) on a side surface of the inner tank wall facing towards the storage space.  
25

Further, a heat exchanger according to the present invention may be integrated with the inner tank wall (10) on a side surface of the inner tank wall facing away from the storage space.

30 Further, a surface area of a heat exchanger according to the present invention may be in thermal contact with stored cryogenic fluid, which surface spans up to a whole inner surface area of the storage space.

Further, a heat exchanger according to the present invention may comprise at least  
35 one thin steel plate with corrugations (11), wherein the thin corrugated steel plate (11) is spot-welded (12) onto the inner tank wall.

Further, a cryogenic storage tank using a heat exchanger according to the present invention may be a cylinder-shaped tank, or a spherical shaped tank, or an elongated tank.

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Further, a heat exchanger according to the present invention may comprise a cooling fluid applied in a space (19) constituted between corrugations of a thin steel plate (11) and an inner tank wall.

10 Further, a heat exchanger according to the present invention may comprise cooling fluid being delivered from a cooling machine via an inlet pipe connected to the heat exchanger, and wherein an outlet pipe connected to the heat exchanger returns cooling fluid to the cooling machine.

15 Further, wherein the spot-welded (12) corrugated steel plate (11) provides increased mechanical integrity of the inner steel wall of the storage tank.

Further, a heat exchanger according to the present invention may be is arranged inside a vacuum space provided between an outer steel wall and an inner steel wall arranged apart from each other in a cryogenic storage tank.

20

Further, a heat exchanger according to the present invention may comprise at least two corrugated thin steel plates (11a, 11b) welded together and onto an internal surface area of a storage tank wall.

25

Further, a heat exchanger according to the present invention may comprise a leakage detection gas deployed in a space between at least two corrugated thin steel plates (11a, 11b).

30 Further, a heat exchanger according to the present invention may comprise a flat steel plate (10a) arranged with a corrugated thin steel plate (11) on one side of the flat plate (10a), wherein the heat exchanger may be mounted along a center line of the storage space of the cryogenic storage tank.

According to an example of embodiment of the present invention, a system of transferring cryogenic fluid with a specified quality from a first cryogenic tank to a second tank is done with a pipe arranged with a heat exchanger around the periphery of the pipe cooling the pipe during the transfer.

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Further, embodiments of the present invention may be used in a transport truck.

Further, embodiments of the present invention may be used in fuel tanks in vessels.

10 According to an example of embodiments of the present invention, a method of mounting a heat exchanger according to the present invention inside a cryogenic tank comprises steps of:

- 15 - mounting at least one vent (18) onto a surface of at least one thin steel plate (11),
- spotwelding (12) the at least one thin steel plate (11) with the at least one mounted vent (18) onto an inner surface (10) of the cryogenic tank,
- the spot welding (12) is done in a regular pattern on the at least one thin steel plate (11),
- 20 - attaching a pipe (17) to the at least one vent (18) and apply high pressurized water into the backside of the at least one thin steel plate (11) thereby creating a plurality of protruding corrugations in between the regular pattern of the spot welding (12),
- removing the at least one attached vent (18) and close the opening left after removal of the at least one vent (18), and
- 25 - welding the circumference of the at least one thin steel plate (11) creating a closed space (19) between the at least one thin steel plate (11) and the inner surface (10) of the cryogenic storage tank.

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Claims:

1. A cryogenic storage tank comprising a cooling heat exchanger having a defined width and length,  
5  
- wherein the heat exchanger is integrated with an inner tank wall (10) of the storage space of the cryogenic storage tank, wherein a surface area of the heat exchanger provided by the defined width and length of the heat exchanger is in thermal contact with cryogenic fluid stored in the tank.  
10
2. The storage tank of claim 1, wherein the heat exchanger is integrated with the inner tank wall (10) on a side surface of the inner tank wall facing towards the storage space.
- 15 3. The storage tank of claim 1, wherein the heat exchanger is integrated with the inner tank wall (10) on a side surface of the inner tank wall facing away from the storage space.
4. The storage tank of claim 1, wherein the surface area of the heat exchanger in  
20 thermal contact with stored cryogenic fluid spans up to a whole inner surface area of the storage space.
5. The storage tank of claim 2 or 3, wherein the heat exchanger comprises at least one thin steel plate with corrugations (11), wherein the thin corrugated  
25 steel plate (11) is spot-welded (12) onto the inner tank wall.
6. The storage tank of claim 1, wherein the tank is a cylinder-shaped tank, or a spherical shaped tank, or an elongated tank.
- 30 7. The storage tank of claim 5, wherein a cooling fluid is applied in a space (19) constituted between the corrugations of the thin steel plate (11) and the inner tank wall.
8. The storage tank of claim 7, wherein a cooling fluid is delivered from a cooling  
35 machine via an inlet pipe connected to the heat exchanger,  
and wherein an outlet pipe connected to the heat exchanger returns cooling fluid to the cooling machine.

9. The storage tank of claim 5, wherein the spot-welded (12) corrugated steel plate (11) provides increased mechanical integrity of the inner steel wall of the storage tank.

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10. The storage tank of claim 1, wherein the heat exchanger according to claim 1 is arranged inside a vacuum space provided between an outer steel wall and an inner steel wall arranged apart from each other.

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11. The storage tank of claim 5, wherein at least two corrugated thin steel plates (11a, 11b) are welded together and onto the internal surface area of the wall.

12. The storage tank of claim 11, wherein a leakage detection gas is deployed in a space between the at least two corrugated thin steel plates (11a, 11b).

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13. The storage tank of claim 1, wherein the heat exchanger comprises a flat steel plate (10a) arranged with a corrugated thin steel plate (11) on one side of the flat plate (10a), wherein the heat exchanger is mounted along a center line of the storage space of the cryogenic storage tank.

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14. A system of transferring cryogenic fluid with a specified quality from a first cryogenic tank according to claim 1 to a second storage tank comprises a pipe arranged with a heat exchanger around the periphery of the pipe cooling the pipe during the transfer.

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15. Use of a tank according to claim 1 in a transport truck.

16. Use of a tank according to claim 1 as a fuel tank in vessels.

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17. A method of mounting a heat exchanger according to claim 5 inside a cryogenic tank comprising steps of:

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- mounting at least one vent (18) onto a surface of at least one thin steel plate (11),
- spotwelding (12) the at least one thin steel plate (11) with the at least one mounted vent (18) onto an inner surface (10) of the cryogenic tank,
- the spot welding (12) is done in a regular pattern on the at least one thin steel plate (11),

- attaching a pipe (17) to the at least one vent (18) and apply high pressurized water into the backside of the at least one thin steel plate (11) thereby creating a plurality of protruding corrugations in between the regular pattern of the spot welding (12),
- removing the at least one attached vent (18) and close the opening left after removal of the at least one vent (18), and
- welding the circumference of the at least one thin steel plate (11) creating a closed space (19) between the at least one thin steel plate (11) and the inner surface (10) of the cryogenic storage tank.

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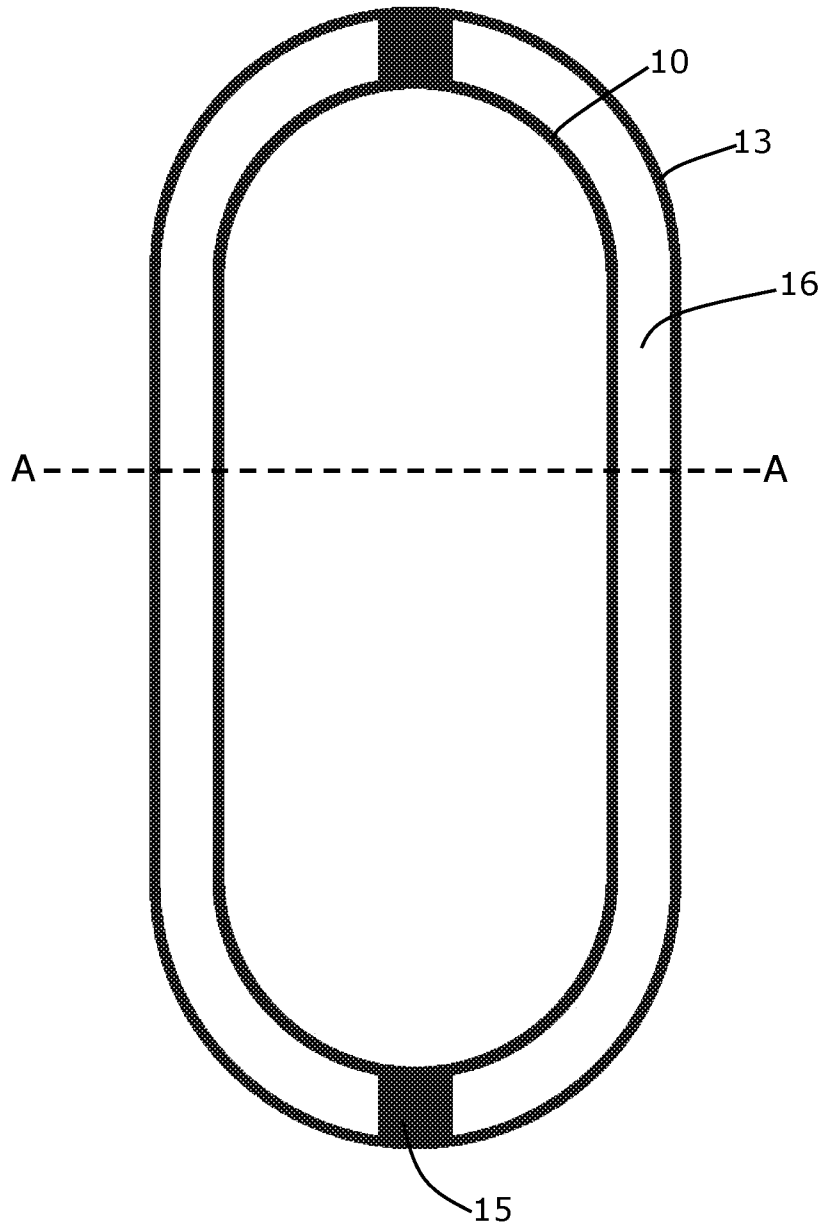


Figure 1

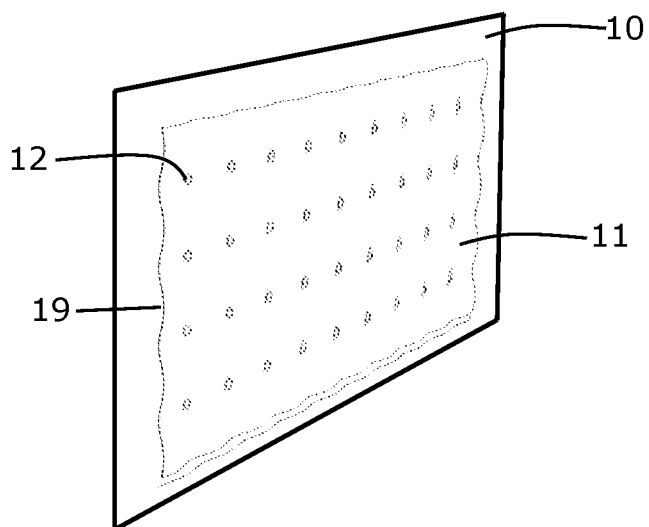


Figure 2A

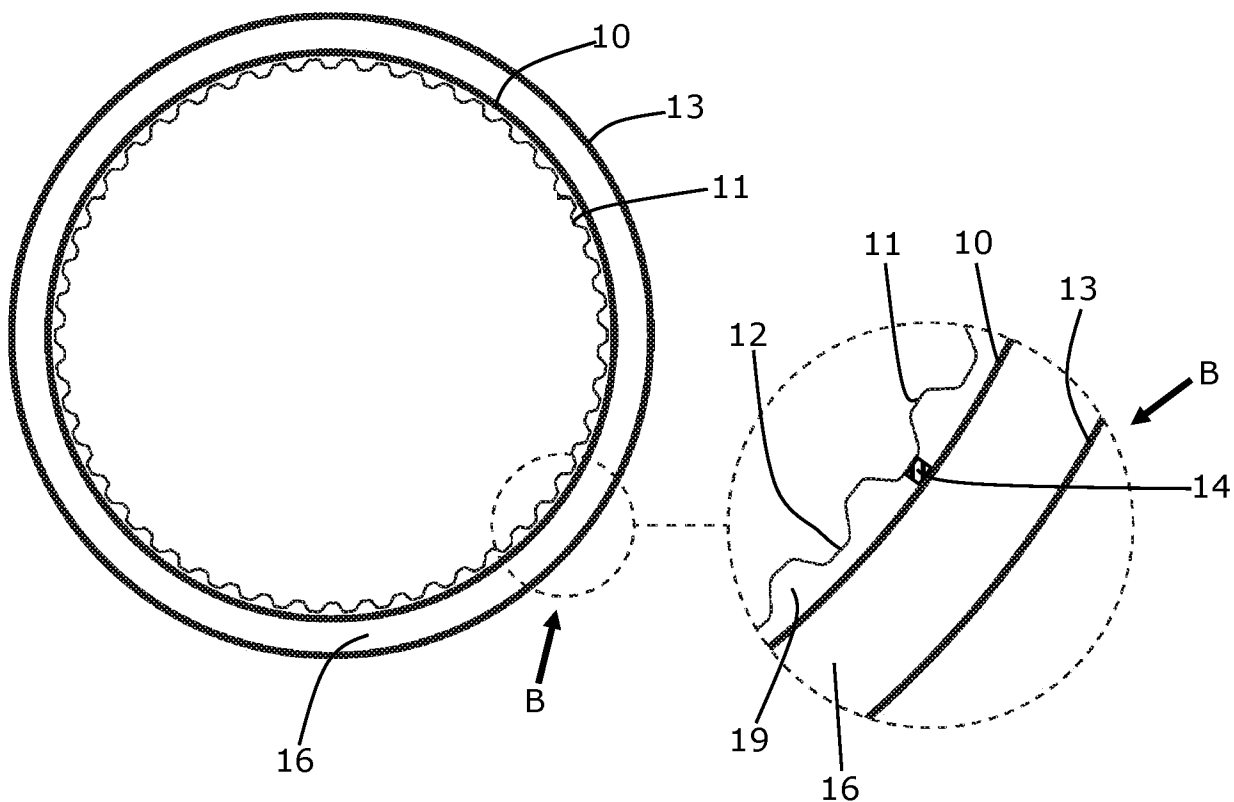


Figure 2B



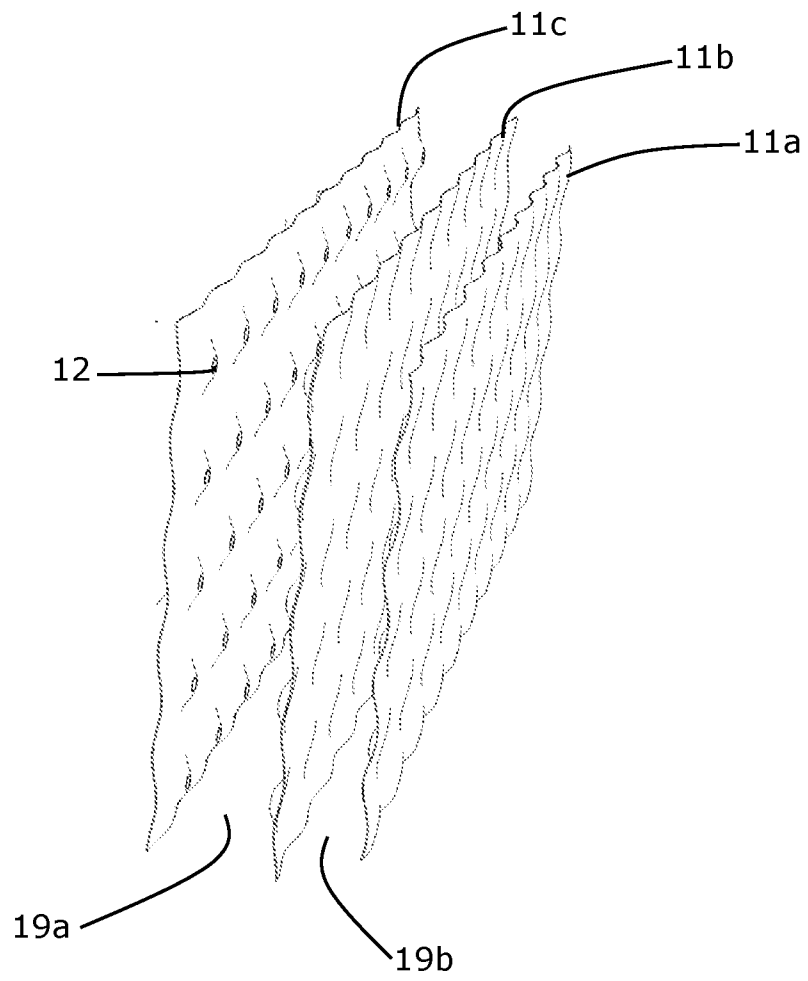


Figure 4

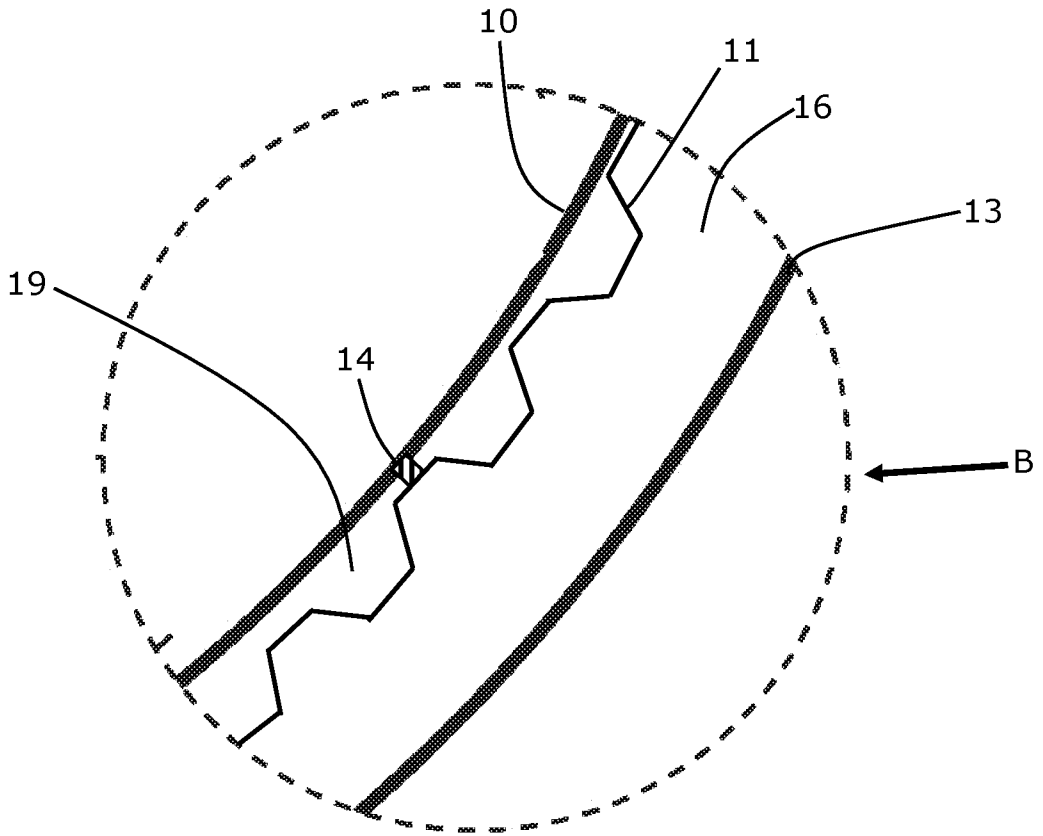


Figure 5

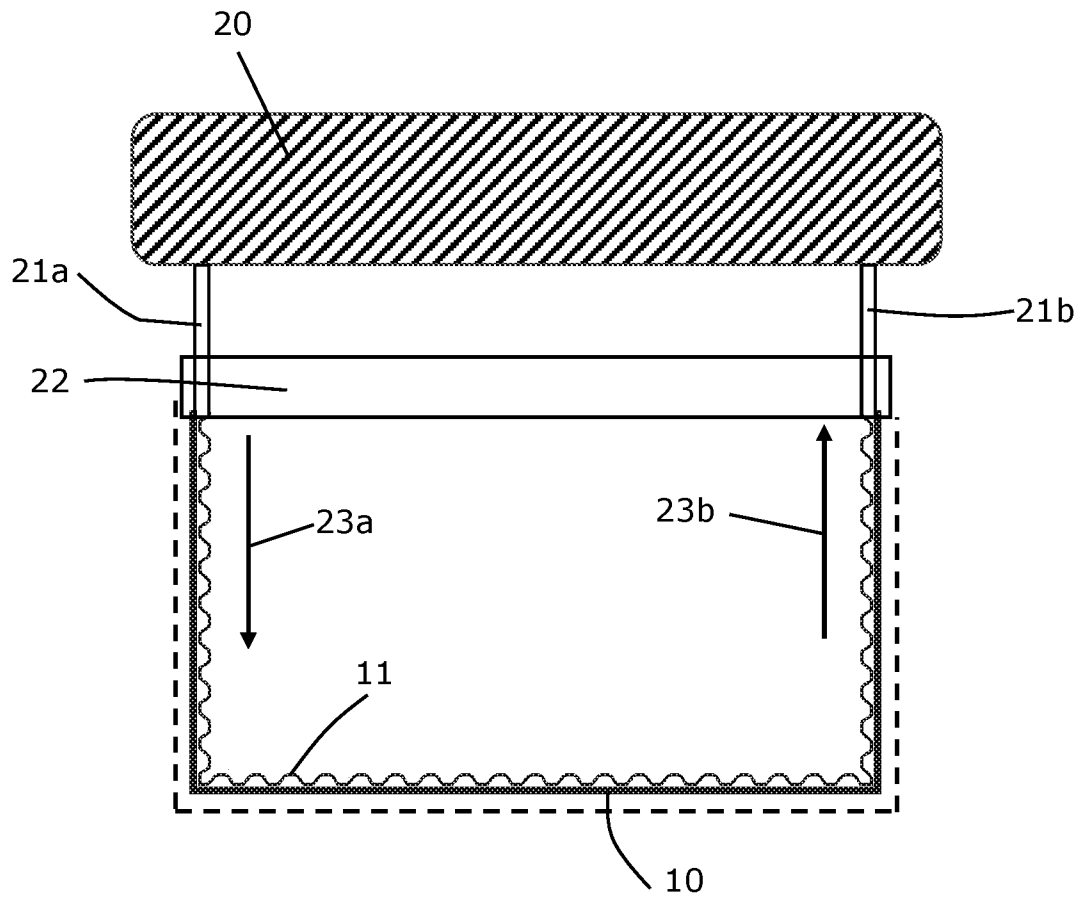


Figure 6

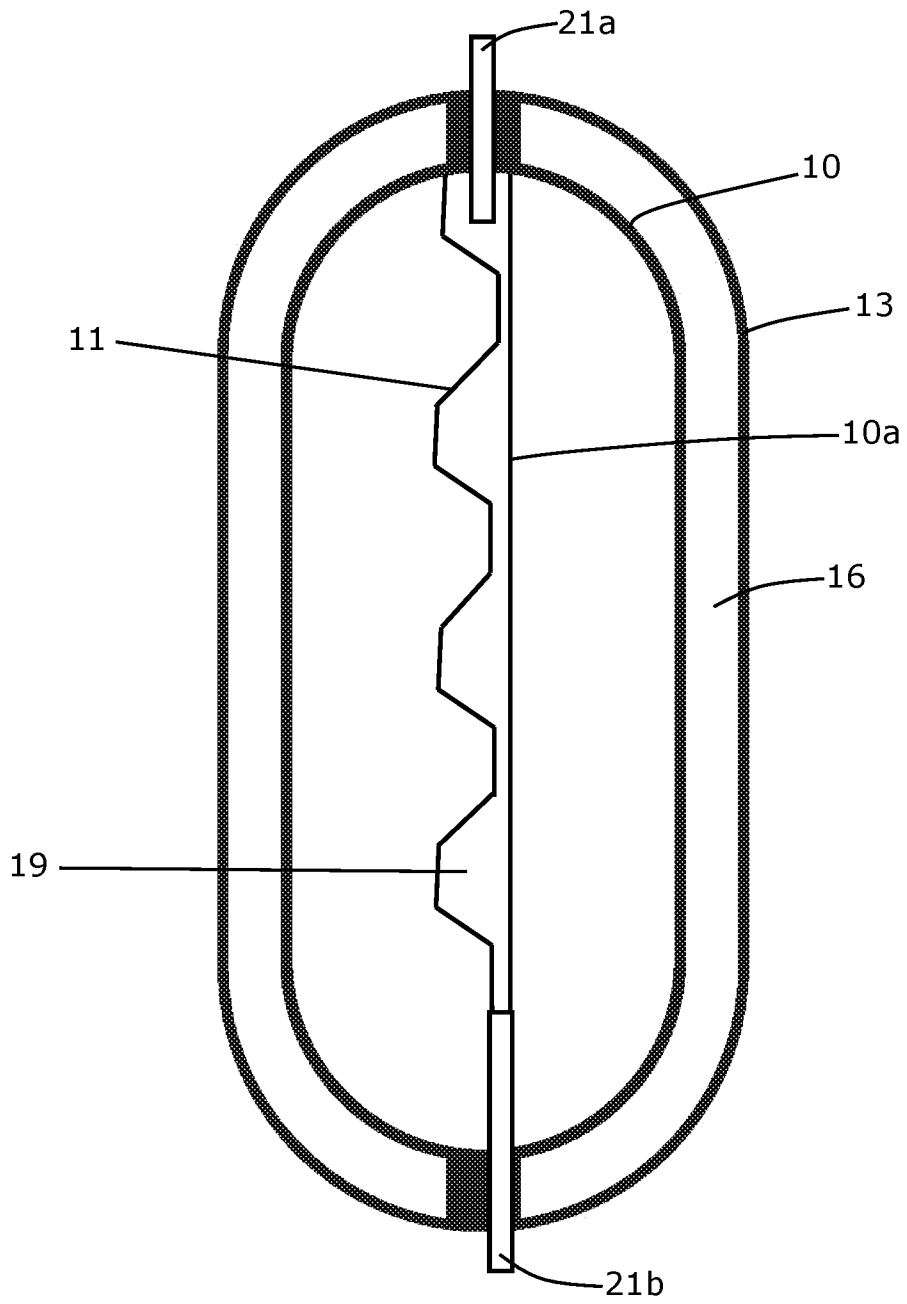


Figure 7