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(71) Applicant: **WÄRTSILÄ FINLAND OY** [FI/FI]; Tarhaajantie 2, 65380 Vaasa (FI).

(72) Inventors: **JANSSON, Mathias**; c/o Wärtsilä Finland Oy, Järvikatu 2-4, 65100 Vaasa (FI). **RÅHOLM, Martin**; c/o Wärtsilä Finland Oy, Järvikatu 2-4, 65100 Vaasa (FI). **MALYS, Marcin**; Luzycka Str 6e, 81-537 Gdynia (PL). **ADAMOWICZ, Maciej**; Luzycka Str 6e, 81-537 Gdynia (PL). **KOCZUR-GRAZAWSKA, Malgorzata**; Luzycka Str 6e, 81-537 Gdynia (PL). **SLUSARSKI, Grzegorz**; Luzycka Str 6e, 81-537 Gdynia (PL).

(74) Agent: **BERGGREN OY**; P.O. Box 16 (Eteläinen Rautatiekatu 10 A), 00101 Helsinki (FI).

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(54) Title: BILOBE OR MULTILOBE TANK

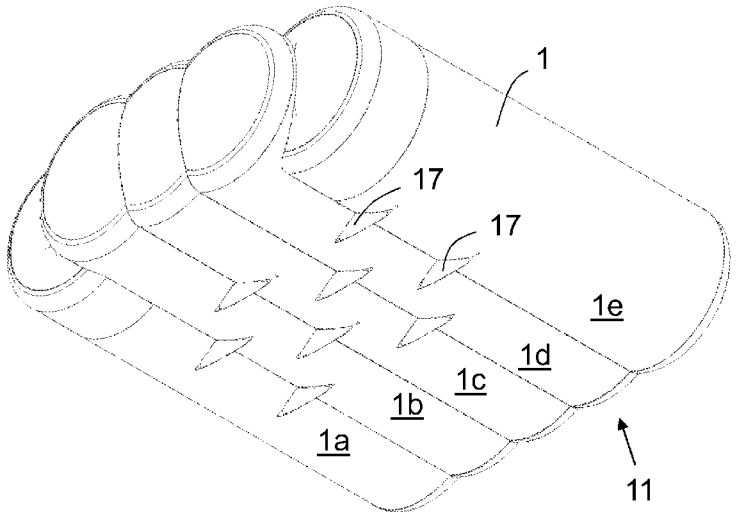

FIG. 5

(57) Abstract: The bilobe or multilobe tank (1) for storing liquefied natural gas comprises at least two tank sections (1a, b, 1c, 1d, 1e), each tank section (1a, 1b, 1c, 1d, 1e) having a curved upper surface and curved bottom surface, the tank sections (1a, 1b, 1c, 1d, 1e) being joined to each other so that the tank (1) has an undulating upper surface (12) and an undulating lower surface (11). Each tank section (1a, 1b, 1c, 1d, 1e) is connect- ed to an adjacent tank section (1a, 1b, 1c, 1d, 1e) with at least one horizontal connecting duct (17, 18) so that a horizontal flow path is formed between the lower- most points (13) of the adjacent tank sections (1a, 1b, c, 1d, 1e) or between the uppermost points (16) of the adjacent tank sections (1a, 1b, 1c, 1d, 1e).

[Continued on next page]

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Bilobe or multilobe tank

Technical field of the invention

The present invention relates to a bilobe or multilobe tank for storing liquefied natural gas in accordance with the preamble of claim 1.

Background of the invention

Natural gas, or in general mixtures of hydrocarbons that are volatile enough to make the mixture appear in gaseous form in room temperature, constitutes an advantageous alternative to fuel oil as the fuel of internal combustion engines. In sea-going vessels that use natural gas as fuel, the natural gas is typically stored onboard in liquid form, giving rise to the commonly used acronym LNG (Liquefied Natural Gas). Natural gas can be kept in liquid form by maintaining its temperature below a boiling point, which is approximately -162 degrees centigrade. LNG is usually stored at a pressure that is close to the atmospheric pressure, but large tanks used for storing LNG need to withstand significant hydrostatic pressures and a certain overpressure. For achieving good mechanical strength, LNG tanks are typically constructed as cylindrical or spherical containers. However, for practical reasons, large LNG tanks are sometimes designed as bilobe or multilobe tanks instead of cylindrical tanks. A bilobe tank comprises two mating curved halves, for instance two spherical caps or two cylindrical segments. A multilobe tank comprises at least three curved sections that are joined to each other. The sections can be partial cylinders or spheres.

An LNG tank having a shape of a horizontal cylinder has a bottom level running along a line in the bottom of the cylinder. Similarly, it has a top level running along a line in the top of the cylinder. An outlet for discharging liquefied gas can be located anywhere along the bottom level and a pressure relieve valve can be located anywhere along the top level. Since a multilobe tank can comprise several parallel cylindrical or spherical segments, the bottom level is not defined by a single line but by several lines separated from each other by raised sections. Similarly, the top level is defined by several lines separated from each other by lowered sections. For enabling complete emptying of a multilobe tank, several outlets are thus needed. For safety reasons, it is im-

portant that all those spaces that hold fluid in gas phase are directly connected to a pressure relief valve. Otherwise, overpressure may spill fluid that is in liquid phase out of the tank. This limits the maximum liquid level in a multilobe tank.

Summary of the invention

An object of the present invention is to provide an improved bilobe or multilobe tank for storing liquefied natural gas. The characterizing features of the tank arrangement according to the invention are given in the characterizing part of claim 1.

The tank according to the invention comprises at least two tank sections, each tank section having a curved upper surface and curved bottom surface, the tank sections being joined to each other so that the tank has an undulating upper surface and an undulating lower surface. Each tank section is connected to an adjacent tank section with at least one horizontal connecting duct so that a horizontal flow path is formed between the lowermost points of the adjacent tank sections or between the uppermost points of the adjacent tank sections.

By connecting the lowermost points of the tank sections, a single outlet is sufficient for emptying a bilobe or multilobe tank. By connecting the uppermost points of the tank sections, gas flow between the tank sections is allowed regardless of the liquid level inside the tank, which increases safety.

According to an embodiment of the invention, the tank comprises at least one lower connecting duct for connecting the lowermost points of two adjacent tank sections and at least one upper connecting duct for connecting the uppermost points of two adjacent tank sections.

According to an embodiment of the invention, the connecting ducts are bulges, which are perpendicular to the longitudinal axis of the tank and join to the walls of the tank outside the tank.

According to an embodiment of the invention, each tank section has a shape of a segment of a horizontal cylinder.

According to an embodiment of the invention, an inlet for a pressure relief valve is arranged at an uppermost point of the tank.

According to an embodiment of the invention, the tank is provided with an outlet that is arranged at the lowermost point of the tank.

A sea-going vessel according to the invention comprises a bilobe or multilobe tank defined above.

Brief description of the drawings

Embodiments of the invention are described below in more detail with reference to the accompanying drawings, in which

Fig. 1 shows a cross-sectional view of a ship comprising an LNG tank arrangement,

Fig. 2 shows a top view of the tank arrangement of figure 1,

Fig. 3 shows a side view of the tank arrangement,

Fig. 4 shows an end view of a multilobe tank according to an embodiment of the invention, and

Fig. 5 shows a perspective view of the multilobe tank of figure 4.

Description of embodiments of the invention

Figures 1 to 3 show an LNG tank arrangement of a ship 2. The arrangement comprises an LNG tank 1. The LNG tank 1 is a container that is configured to store liquefied natural gas. Natural gas is kept in liquid form by maintaining its temperature below a boiling point, which is approximately -162 degrees centigrade. The LNG tank 1 is located in a tank hold 3, which is located around the longitudinal center line of the ship 2. The LNG tank 1 stores liquefied gas that is used as fuel in one or more engines of the ship 2.

The LNG tank 1 has a single shell structure. The space holding the LNG is formed by a shell 6 that is made of a cold resistant material. The expression

"cold resistant material" refers to a material that can withstand the temperature of liquefied natural gas. Minimum design temperature of the material should be at most -165 °C. The material can be, for instance, stainless steel. Suitable materials are, for instance, 9 % nickel steel, low manganese steel, austenitic steels, such as types 304, 304L, 316, 316L, 321 and 347 and austenitic Fe-Ni alloy (36 % nickel). An insulation layer 7 is arranged around the shell 6. The insulation layer 7 can be made of, for instance, polyurethane.

The LNG tank 1 is a multilobe tank. The expression "multilobe tank" refers here to a tank that comprises at least three tank sections that have a curved cross-sectional profile and which are joined to each other such that the shell 6 of the tank 1 has an undulating shape at least on two sides. In the embodiment of the figures, the LNG tank 1 comprises five tank sections 1a, 1b, 1c, 1d, 1e each having the shape of a partial cylinder. The longitudinal center lines of the tank sections 1a, 1b, 1c, 1d, 1e are parallel to each other. The centermost tank section 1c has a shape that is formed by cutting a segment from a horizontal cylinder by two vertical planes. The other tank sections 1a, 1b, 1d, 1e each have a shape that is formed by cutting a segment from a horizontal cylinder by one vertical plane. The sections 1a, 1b, 1c, 1d, 1e of the tank 1 are arranged in a row in a horizontal plane. The outermost tank sections 1a, 1e are shorter than the three sections 1b, 1c, 1d in the middle of the LNG tank 1. The ends of the tank sections 1a, 1b, 1c, 1d, 1e are closed by end caps 4a, 4b, 4c, 4d, 4e, 5a, 5b, 5c, 5d, 5e. The end caps can have a shape of a spherical cap or part of a spherical cap.

Figures 4 and 5 show a multilobe tank 1 according to an embodiment of the invention. The tank 1 can be used in the tank arrangement of figures 1 to 3. In figures 4 and 5, the tank 1 is shown without the insulation. The tank 1 is configured to be arranged in a horizontal position. The tank 1 has a bottom 11 and top 12. When in use, the top 12 faces upwards and the bottom 11 faces downwards. Since the tank sections 1a, 1b, 1c, 1d, 1e forming the tank 1 are segments of horizontal cylinders, both the bottom surface and the top surface has an undulating shape. Each of the surfaces thus has a cross-sectional shape of a wave, where troughs 13, 15 and crests 14, 16 alternate. Inside the tank 1, the uppermost points of tank 1 are located at the areas of the crests 16 of the tops 12 and the lowermost points are located at the areas of the troughs 13 of the bottom 11. Between the troughs 13 of the bottom 11 there are raised sections. Between the crests 16 of the top 12 there are lowered sections.

When the liquid level inside the tank 1 is below the crests 14 of the bottom, direct flow of liquid between the tank sections 1a, 1b, 1c, 1d, 1e is not allowed. If the liquid level inside the tank 1 is above the troughs 15 of the top 12, direct gas flow between the between the tank sections 1a, 1b, 1c, 1d, 1e is not allowed. For allowing flow between the tank sections 1a, 1b, 1c, 1d, 1e with all liquid levels, the tank 1 has been provided with horizontal connecting ducts 17, 18. The upper part of the tank 1 comprises upper connecting ducts 18 and the lower part of the tank comprises lower connecting ducts 17.

Each tank section 1a, 1b, 1c, 1d, 1e is connected to an adjacent tank section with at least one upper connecting duct 18. The upper connecting duct 18 is configured to form a horizontal flow path between the uppermost points of the adjacent tank sections 1a, 1b, 1c, 1d, 1e. This ensures that gas flow between the tank sections 1a, 1b, 1c, 1d, 1e is allowed regardless of the liquid level in the tank 1. In the embodiment of the figures, each tank section 1a, 1b, 1c, 1d, 1e is connected to the adjacent tank sections on both sides with upper connecting ducts 18. An inlet for a pressure relief valve can be arranged at an uppermost point of any of the tank sections 1a, 1b, 1c, 1d, 1e. The tank 1 can be provided with a pressure relief valve comprising an inlet pipe, and the pressure relief valve does thus not need to be located at an uppermost point of the tank 1, but it is sufficient that the inlet pipe opens to the uppermost point and allows gas flow to the pressure relief valve.

Each tank section 1a, 1b, 1c, 1d, 1e is also connected to an adjacent tank section with at least one lower connecting duct 17. The lower connecting duct 17 is configured to form a horizontal flow path between the lowermost points of the adjacent tank sections 1a, 1b, 1c, 1d, 1e. This ensures that liquid flow between the tank sections 1a, 1b, 1c, 1d, 1e is allowed regardless of the liquid level in the tank 1. In the embodiment of the figures, each tank section 1a, 1b, 1c, 1d, 1e is connected to the adjacent tank sections on both sides with lower connecting ducts 17. An outlet for discharging LNG from the tank 1 can be arranged at a lowermost point of any of the tank sections 1a, 1b, 1c, 1d, 1e.

In the embodiment of the figures, the upper and lower connecting ducts 17, 18 are bulges, which are perpendicular to the longitudinal axis 19 of the tank 1. The bulges join to the walls of the tank 1 outside the tank 1. The connecting ducts 17, 18 are joined to the tank 1 by welding. On the upper surface of the tank 1, the upper edges of the upper connecting ducts 18 are in the vertical di-

rection at the same level as the uppermost points of the tank sections 1a, 1b, 1c, 1d, 1e. On the lower surface of the tank 1, the lower edges of the lower connecting ducts 17 are in the vertical direction at the same level as the lowermost points of the tank sections 1a, 1b, 1c, 1d, 1e.

As shown in figure 5, each tank section 1a, 1b, 1c, 1d, 1e can be connected to an adjacent tank section with more than one lower connecting duct 17. In figure 5, each tank section 1a, 1b, 1c, 1d, 1e is connected to the adjacent tank section on the left with two lower connecting ducts 17 and to the tank section on the right with two lower connecting ducts 17. Consecutive connecting ducts 17 are arranged at a distance from each other in the direction of the longitudinal axis 19 of the tank 1. The upper connecting ducts 18 can be arranged in the same way as the lower connecting ducts 17 in figure 5.

It will be appreciated by a person skilled in the art that the invention is not limited to the embodiments described above, but may vary within the scope of the appended claims. For instance, instead of being a multilobe tank, the LNG tank could be a bilobe tank having only two sections.

Claims

1. A bilobe or multilobe tank (1) for storing liquefied natural gas, the tank comprising at least two tank sections (1a, 1b, 1c, 1d, 1e), each tank section (1a, 1b, 1c, 1d, 1e) having a curved upper surface and curved bottom surface, the tank sections (1a, 1b, 1c, 1d, 1e) being joined to each other so that the tank (1) has an undulating upper surface (12) and an undulating lower surface (11), **characterized** in that each tank section (1a, 1b, 1c, 1d, 1e) is connected to an adjacent tank section (1a, 1b, 1c, 1d, 1e) with at least one horizontal connecting duct (17, 18) so that a horizontal flow path is formed between the lowermost points (13) of the adjacent tank sections (1a, 1b, 1c, 1d, 1e) or between the uppermost points (16) of the adjacent tank sections (1a, 1b, 1c, 1d, 1e).

2. A tank (1) according to claim 1, wherein the tank (1) comprises at least one lower connecting duct (17) for connecting the lowermost points (13) of two adjacent tank sections (1a, 1b, 1c, 1d, 1e) and at least one upper connecting duct (18) for connecting the uppermost points (16) of two adjacent tank sections (1a, 1b, 1c, 1d, 1e).

3. A tank (1) according to claim 1 or 2, wherein the connecting ducts (17, 18) are bulges, which are perpendicular to the longitudinal axis (19) of the tank (1) and join to the walls of the tank (1) outside the tank (1).

4. A tank (1) according to any of claims 1 to 3, wherein each tank section (1a, 1b, 1c, 1d, 1e) has a shape of a segment of a horizontal cylinder.

5. A tank (1) according to any of the preceding claims, wherein an inlet for a pressure relief valve is arranged at an uppermost point (16) of the tank (1).

6. A tank (1) according to any of the preceding claims, wherein the tank (1) is provided with an outlet that is arranged at the lowermost point (13) of the tank (1).

7. A sea-going vessel (2) comprising a bilobe or multilobe tank (1) according to any of the preceding claims.

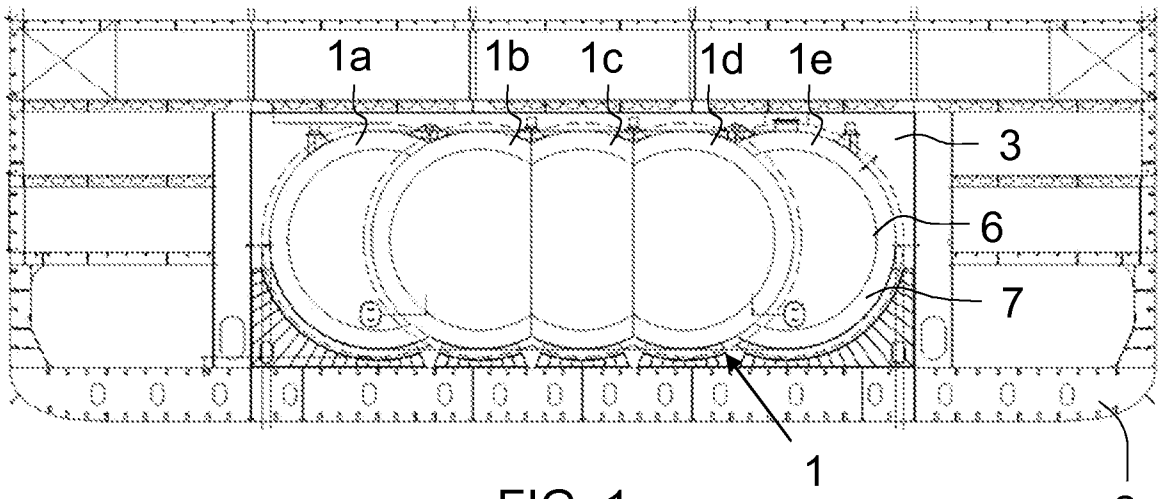

FIG. 1

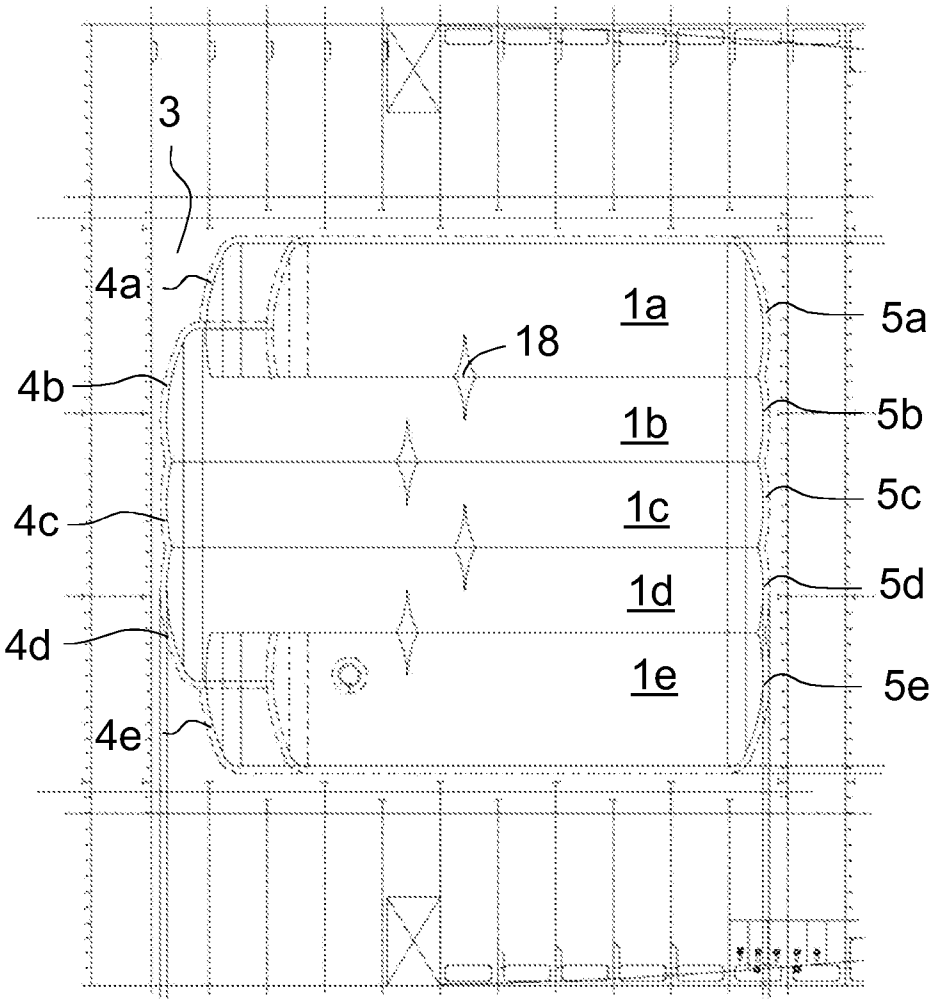

FIG. 2

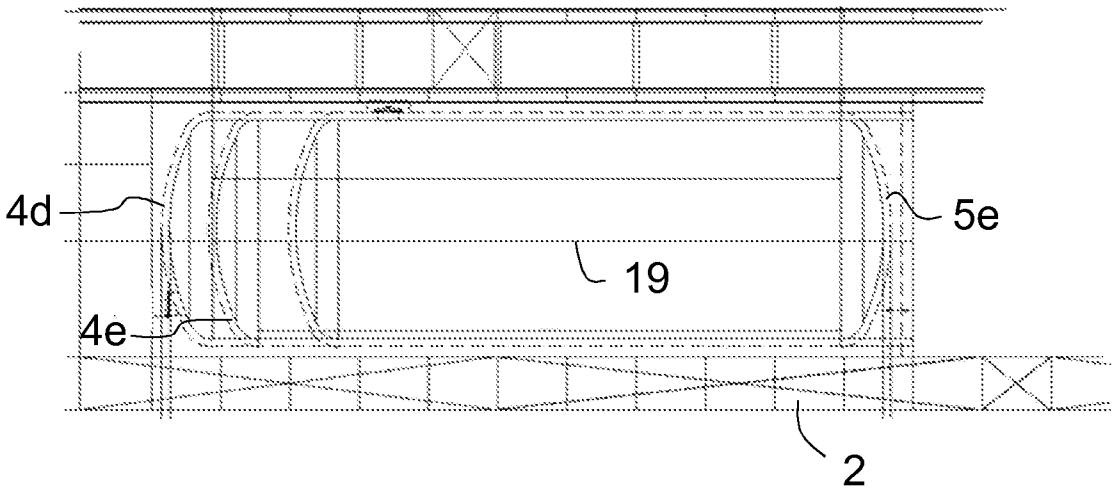

FIG. 3

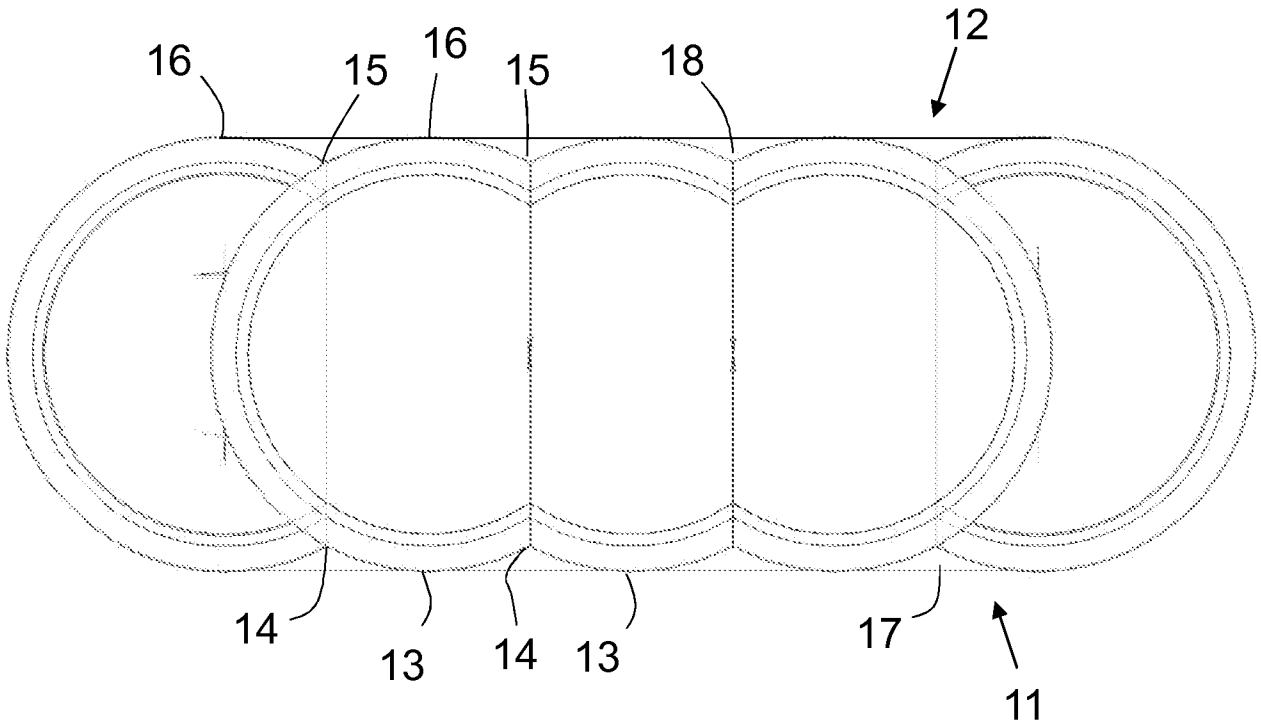

FIG. 4

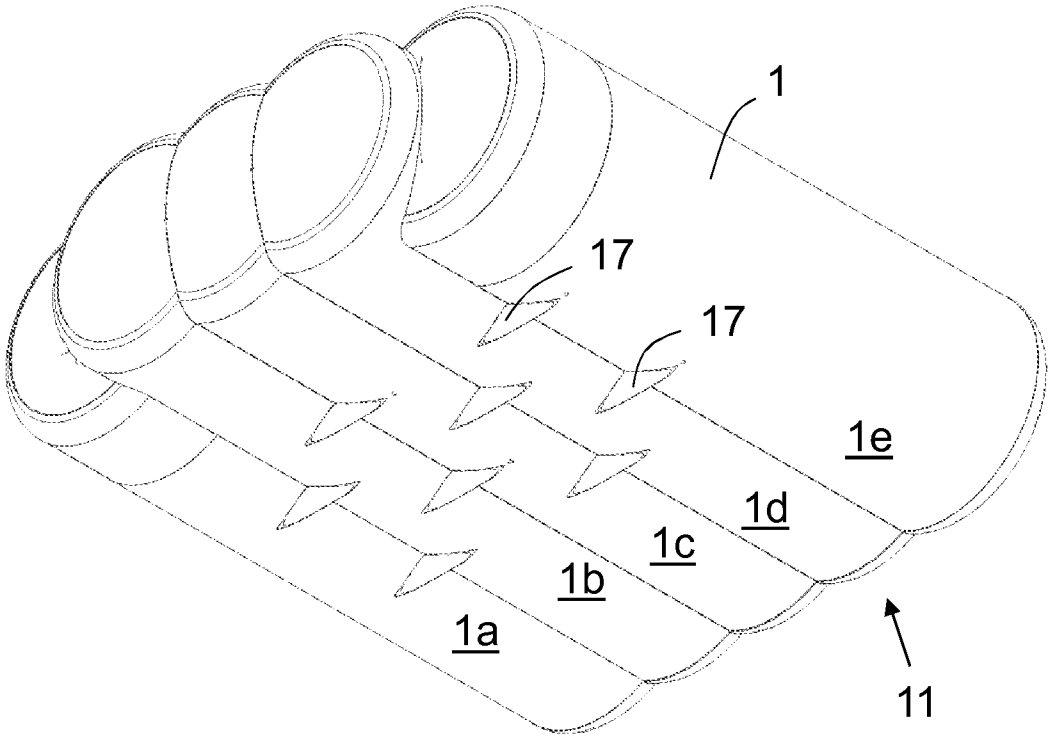

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2016/050305

A. CLASSIFICATION OF SUBJECT MATTER
INV. F17C3/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F17C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	US 3 092 063 A (RENE LEROUX) 4 June 1963 (1963-06-04) columns 2,3; figures 4-7	1-7
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X	US 2 341 044 A (JACKSON JAMES O ET AL) 8 February 1944 (1944-02-08) figure 5	1,3,4,6

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 January 2017	09/02/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Nicol, Boris

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INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2016/050305

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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