(12) **PATENT**

(11) **348617** (13) **B1**

(19) NO

NORWAY (51) Int Cl.

F17C 13/08 (2006.01)
B63B 25/16 (2006.01)
B63B 25/12 (2006.01)
B63B 25/14 (2006.01)
F17C 3/02 (2006.01)
B63B 25/02 (2006.01)
B63B 3/70 (2006.01)
F17C 13/12 (2006.01)
F17C 3/08 (2006.01)

Norwegian Industrial Property Office

(21)	Application nr.	20221390	(86)	International Filing Date and Application Number
(22)	Date of Filing	2022.12.22	(85)	Date of Entry into National Phase
(24)	Date of Effect	2022.12.22	(30)	Priority
(41)	Publicly Available	2024.06.24		
(45)	Granted	2025.03.31		

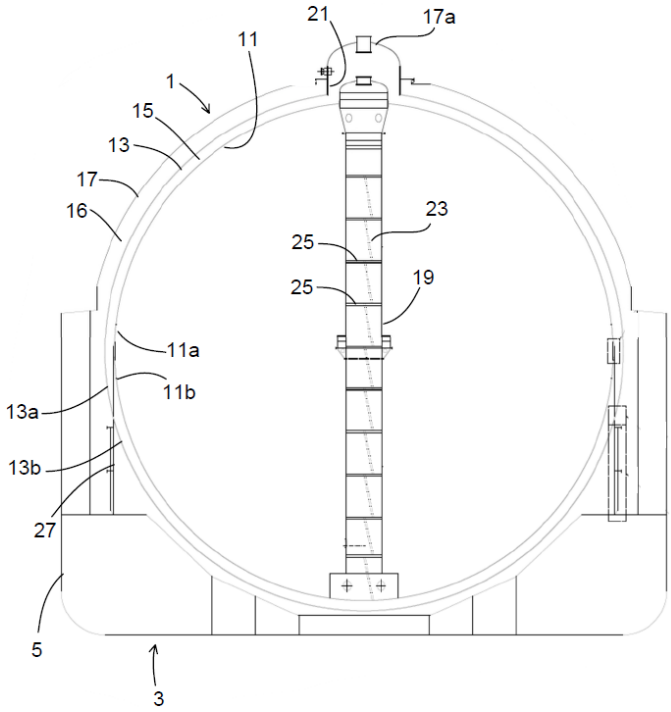
(73) Proprietor Moss Maritime AS, Postboks 120, 1325 LYSAKER, Norge
(72) Inventor Tor Skogan, Underhaugsveien 10C, 1358 JAR, Norge
Jørgen Hveem, Ruglandveien 176 B, 1359 EIKSMARKA, Norge
Frode Fløtten, Brinkvegen 43, 2050 JESSHEIM, Norge
Jørgen Anker, Hovseterveien 42A, 0768 OSLO, Norge
(74) Agent or Attorney BRYN AARFLOT AS, Stortingsgata 8, 0161 OSLO, Norge

(54) Title **A liquefied gas storage tank and a method for manufacturing said tank**

(56) References Cited:
CN 112460472 A, CN 114777009 A, EP 3032161 A1, EP 3950536 A1, EP 3951243 A1, WO 2014132661 A1, US 3425585 A, CN 115419821 A, US 3680323 A, JP H02195099 A

(57) Abstract

A liquified gas storage tank (1) comprising a curved inner shell (11) and a curved outer shell (13), and an insulating space (15) between the inner and outer shells, an upwardly extending support structure (27) configured to support the inner and outer shells (11, 13), as the support structure (27) connects to the outer shell (13). It further comprises an intermediate support (29) extending through the insulating space (15), between the inner shell (11) and the outer shell (13) to support the inner shell (11) within the outer shell (13). The storage tank (1) further comprises a prefabricated X-profile (33) incorporated as a part of the outer shell (13). The X-profile (33) comprises an upwardly extending shell profile (33c) connected to an upper outer shell portion (13a) of the outer shell (13), and a downwardly extending shell profile (33b) connected to a lower outer shell portion (13b) of the outer shell (13). The X-profile (33) further comprises an upwardly extending interface profile (33d) that connects to the intermediate support (29) and a downwardly extending interface profile (33a) that connects to the support structure (27). A method is also disclosed.



Technical Field

[0001] The present invention relates to a storage tank suitable for storing liquified gases such as hydrogen. The storage tank is suitable for installation on a seagoing vessel for transporting liquified gases.

Background Art

[0002] Storage tanks intended for storage of cooled, liquified gases have been well known for some time. For instance, publication US3680323 from 1972 presents a spherical tank that is supported on an annular skirt. The lower and upper edges of the annular skirt attach to a hull of a marine vessel and to the tank, respectively. The skirt takes up dimensional changes resulting from temperature variations in the tank.

[0003] Furthermore, it is known to provide the storage tank with an inner and an outer shell to obtain a thermal insulated tank. Examples of such double-walled storage tanks are found in US4140073 and US10208886B2, where the tanks are installed in seagoing vessels. Another example is found in publication US7690208B2, where an inner tank is vacuum insulated inside an outer tank to reduce heat convection.

[0004] Furthermore, CN112460472A discloses a spherical Dewar flask type double tank with a support structure going through the outer tank and supporting the inner tank.

[0005] Publication JP H02195099A describes a double spherical tank with internal and external spheres that are supported with skirts. A piece of heat-insulating material is introduced between the supports that transmit forces between the inner and outer spheres.

[0006] In some embodiments of such double-walled tanks, the inner wall is supported by an insulation material arranged in the space between the inner and outer walls. In other embodiments, however, one may wish to avoid such insulation material, leaving the said space void. In such embodiments, it is desirable to arrange a supporting structure for the inner tank / inner wall, that tolerates large temperature differences and that minimizes heat transfer.

Summary of invention

[0007] According to a first aspect of the present invention, there is provided a liquified gas storage tank comprising a curved inner shell and a curved outer shell, and an insulating space between the inner and outer shells. It has an upwardly extending support structure configured to support the inner and outer shells. The support structure connects to the outer shell. It further comprises an intermediate support extending through the insulating space, between the inner shell and the outer shell to support the inner shell within the outer shell. According to the first aspect of the invention, the storage tank further comprises a prefabricated X-profile incorporated as a part of the outer shell. The X-profile comprises an upwardly extending shell profile connected to an upper outer shell portion of the outer shell and a downwardly extending shell profile connected to a lower outer shell portion of the outer shell. Furthermore, the X-profile further comprises an upwardly extending interface profile that connects to the intermediate support and a downwardly extending interface profile that connects to the support structure. The intermediate support is vertically arranged and with the shape of a vertical cylinder.

[0008] When stating that the X-profile is a prefabricated profile, it is meant that the X-profile, comprising the downwardly extending interface profile, the downwardly extending shell profile, the upwardly extending shell profile and the upwardly extending interface profile, is manufactured prior to being connected to the respective interfacing parts.

[0009] The liquified gas storage tank may further comprise a support profile having an upwardly extending shell profile that connects to an upper inner shell portion of the inner shell, a downwardly extending shell profile that connects to a lower inner shell portion of the inner shell, and a downwardly extending interface profile that connects to the intermediate support.

[0010] Advantageously, the support profile can be prefabricated, such as the X-profile.

[0011] The intermediate support can then extend between upwardly extending interface profile of the X-profile and the downwardly extending interface profile of the support profile.

[0012] The liquified gas storage tank can contain liquified hydrogen. The hydrogen may be at a temperature that corresponds to a tank operating pressure near atmospheric pressure. In such embodiments, it is advantageous to limit the heat ingress into the liquid.

[0013] The X-profile can extend along the entire circumference of the outer shell. Moreover, the X-profile can comprise a plurality of X-profile segments that are assembled into a ring.

[0014] Moreover, in such and other embodiments, the respective X-profile segments can be machined from a single metal piece.

[0015] Typically, the liquified gas storage tank may be installed inside a hold space which is defined partly by the ship hull structure and partly by a cover arranged above the upper part of the liquified gas storage tank. An insulation material can advantageously be provided on the outside of the tank outer shell or inside the hold space.

[0016] The insulation material provided on the outside of the tank outer shell or in the hold space can contain a hardening foam.

[0017] According to a second aspect of the present invention, there is provided a method of manufacturing a liquified gas storage tank. The liquid gas storage tank comprises an inner shell and an outer shell with an upper outer shell portion and a lower outer shell portion. The method comprises the steps of: a) prefabricating an X-profile comprising an upwardly extending shell profile, a downwardly extending shell profile, an upwardly extending interface profile, and a downwardly extending interface profile; and b): after step a), attaching the upwardly extending shell profile to an upper outer shell portion of an outer shell, the downwardly extending shell profile to a lower outer shell portion of the outer shell, the upwardly extending interface profile to an intermediate support extending between the outer shell and an inner shell, and attaching the downwardly extending interface profile to an upwardly extending

support structure configured to support the outer shell. The intermediate support is vertically arranged and with the shape of a vertical cylinder.

[0018] In some embodiments, step a) may involve milling respective X-profile segments of single pieces of metal.

Detailed description of the invention

[0019] While various features of the invention have been discussed in general terms above, a more detailed and non-limiting example of embodiment will be presented in the following with reference to the drawings, in which

Fig. 1 is a midship cross section view of a ship through the center of a storage tank;

Fig. 2 is an enlarged cross section view of a side portion of the storage tank;

Fig. 3 is a further enlarged portion of a part of Fig. 2;

Fig. 4 is another enlarged portion of a part of Fig. 2; and

Fig. 5 is a schematic perspective view of an X-profile.

[0020] Fig. 1 depicts a storage tank 1 according to the present invention installed on a ship 3. The storage tank 1 has a spherical or near spherical shape. Typically, the ship 3 can carry a plurality of storage tanks 1, arranged in a row along the longitudinal extension of the ship hull 5.

[0021] The storage tank 1 has an inner shell 11 and an outer shell 13. Between the inner and outer shells 11, 13 there is an insulating space 15. The insulating space 15 can advantageously be provided with a reduced pressure (i.e. being below atmospheric pressure). This will reduce the thermal convection between the inner and outer shells 11, 13. Moreover, the insulating space 15 may be void, i.e. being without any insulating material. In other embodiments though, the insulating space 15 may be provided with an insulated material.

[0022] Protecting the storage tank 1 is a cover 17. The cover 17 is, in the shown embodiment, supported at least by the sides of the ship hull 5. The cover 17,

together with portions of the ship hull 5, enclose the storage tank 1 and provides protection such as from humid air and other types of influence.

[0023] Protecting the storage tank 1 is a cover 17. The cover 17 is, in the shown embodiment, supported at least by the sides of the ship hull 5. The cover 17, together with portions of the ship hull 5, enclose the tank in a hold space 16, which provides protection from humid air/surroundings. The hold space 16 can be filled with inert gas or dry air and will have space for mounting of auxiliary insulating foam (e.g. polyurethane foam) or other insulation means on the surface of the outer shell 13. The insulating material on the surface of the outer shell 13 or in the hold space 16 will provide a backup in a situation where the insulating characteristic of the insulating space 15 is reduced. Such a situation may for instance occur if the pressure inside the insulating space 15 increases

[0024] At the upper portion of the cover 17 there is an access portion 17a, through which personnel can access the storage tank 1. Moreover, inside the storage tank 1, i.e. inside the inner shell 11, there is an pipe tower 19. The pipe tower 19 extends from the bottom of the inner shell 11 and up to a tank opening 21 at the upper part of the storage tank 1.

[0025] Ladders 23 or staircases are provided between a plurality of levels 25 inside the pipe tower 19. Moreover, the pipe tower 19 comprises piping (not shown) for transfer of liquid for filling and discharge operations.

[0026] The largest internal horizontal diameter of the storage tank 1 can typically be more than 20 meters, for instance more than 40 meters or even more than 60 meters, depending on the specific need and project. However, the storage tank 1 may also be smaller than this.

[0027] While the storage tank 1 of the discussed embodiment has a spherical design, other designs are possible. For instance, the storage tank 1 may comprise a cylindrical mid portion between an upper and a lower hemispherical portion. Moreover, the upper and/or the lower portion may be somewhat different from a perfect sphere. For instance, the bottom and/or top face may be somewhat flatter than a sphere. This will lower the total height of the storage tank 1 without significantly reducing the total inner volume.

[0028] With embodiments where the insulating space 15 between the inner shell 11 and the outer shell 13 is provided with a reduced pressure, it is considered as beneficial that all faces of the inner shell 11 and the outer shell 13 are provided with a curvature to withstand the pressure difference.

[0029] The outer shell 13 of the storage tank 1 is supported with a support structure 27. In the present embodiment, the support structure 27 has the shape of a cylindrical skirt encircling a lower portion of the storage tank 1.

[0030] Reference is now made to Fig. 2. Fig. 2 depicts, with an enlarged cross section view, the interface between the support structure 27 and the outer shell 13, and the interface between the outer shell 13 and the inner shell 11.

[0031] An intermediate support 29 extends between the outer shell 13 and the inner shell 11, bridging the insulating space 15. Thus, the inner shell 11 is supported by the intermediate support 29 at a distance from the outer shell 13. The intermediate support 29 is vertically arranged, having the shape of a vertical cylinder.

[0032] The inner shell 11 comprises a support profile 31. The support profile 31 is in the shown embodiment arranged along the equatorial line of the spherical shape of the inner shell 11. The support profile 31 has a cross section similar to a small letter "h". It has one upwardly extending shell profile 31a, a downwardly extending shell profile 31c, and a downwardly extending interface profile 31b.

[0033] As shown in Fig. 2 and Fig. 4, the upwardly extending shell profile 31a connects to an upper inner shell portion 11a. Moreover, the downwardly extending shell profile 31c connects to a lower inner shell portion 11b. Furthermore, the downwardly extending interface profile 31b connects to the intermediate support 29. As appears from Fig. 2, the support profile 31 thus constitutes a part of the inner shell 11, together with the upper inner shell portion 11a and the lower inner shell portion 11b.

[0034] As discussed above, the storage tank 1 is supported at least partly by the support structure 27. An X-profile 33 constitutes a part of the outer shell 13. The X-profile 33 comprises a downwardly extending interface profile 33a and a downwardly extending shell profile 33b. Furthermore, the X-profile 33 comprises an upwardly

extending shell profile 33c and an upwardly extending interface profile 33d, as shown in better detail in Fig. 3.

[0035] The X-profile 33 connects to an upper outer shell portion 13a with the upwardly extending shell profile 33c. Moreover, the X-profile 33 connects to a lower outer shell portion 13b with the downwardly extending shell profile 33b. Notably, the two shell profiles 33b, 33c together form a line (or actually a face/plate), such that the two interface profiles 33a, 33d are on respective sides of that line.

[0036] The upwardly extending interface profile 33d connects to the intermediate support 29. The downwardly extending interface profile 33a connects to the support structure 27.

[0037] The X-profile 33 can advantageously be made of stainless steel. However, other alternatives are possible, such as aluminum.

[0038] A schematic perspective view of an X-profile segment 33e is shown in Fig. 5. While this is merely a schematic illustration, it indicates the curvature of the X-profile. The X-profile 33 is assembled by joining a plurality of such X-profile segments 33e into a ring shape. Such joining can for instance occur by welding.

[0039] The X-profile 33 is a prefabricated profile, meaning that the X-profile 33, comprising the downwardly extending interface profile 33a, the downwardly extending shell profile 33b, the upwardly extending shell profile 33c and the upwardly extending interface profile 33d, is manufactured before being connected to the respective interfacing parts (namely the support structure 27, the outer shell 13, and the intermediate support 29).

[0040] In some embodiments, the respective X-profile segments 33e (cf. Fig. 5) are made of one single piece. In such embodiments, the X-profile can be shaped by milling.

[0041] In other embodiments, the respective X-profile segments 33e can be made by welding together separate parts. For instance, the upwardly extending shell profile 33c and the downwardly extending shell profile 33b can be welded onto a curved plate that constitutes the upwardly extending interface profile 33d and the downwardly extending interface profile 33a.

[0042] The possible methods for manufacturing the prefabricated X-profile 33, e.g. milling of one single piece or welding together more parts, can also be used to manufacture the support profile 31. As the skilled reader will appreciate, the support profile 31 can also be assembled by several support profile segments (not shown).

[0043] The attachment of the X-profile 33 to the lower outer shell portion 13b, the upper outer shell portion 13a, the intermediate support 29, and/or the support structure 27 can typically be by means of welding.

[0044] As the skilled person will appreciate, when storing liquid gas, such as liquified hydrogen at or near its boiling point, a significant temperature gradient will exist between the inner shell 11 and the outer shell 13.

Claims

1. A liquified gas storage tank (1) comprising
- a curved inner shell (11) and a curved outer shell (13), and an insulating space (15) between the inner and outer shells,
- an upwardly extending support structure (27) configured to support the inner and outer shells (11, 13), as the support structure (27) connects to the outer shell (13),

and further comprising
- an intermediate support (29) extending through the insulating space (15), between the inner shell (11) and the outer shell (13) to support the inner shell (11) within the outer shell (13),

wherein the storage tank (1) further comprises a prefabricated X-profile (33) incorporated as a part of the outer shell (13), as the X-profile (33) comprises an upwardly extending shell profile (33c) connected to an upper outer shell portion (13a) of the outer shell (13), and a downwardly extending shell profile (33b) connected to a lower outer shell portion (13b) of the outer shell (13), and wherein the X-profile (33) further comprises an upwardly extending interface profile (33d) that connects to the intermediate support (29) and a downwardly extending interface profile (33a) that connects to the support structure (27), **characterized in** that the intermediate support (29) is vertically arranged and with the shape of a vertical cylinder.

2. A liquified gas storage tank (1) according to claim 1, **characterized in** that it further comprises a support profile (31) having an upwardly extending shell profile (31a) that connects to an upper inner shell portion (11a) of the inner shell (11), a downwardly extending shell profile (31c) that connects to a lower inner shell portion (11b) of the inner shell (11), and a downwardly extending interface profile (31b) that connects to the intermediate support (29).

3. A liquified gas storage tank (1) according to claim 1 or claim 2, **characterized in** that it contains liquified hydrogen.

4. A liquified gas storage tank (1) according to one of the preceding claims, **characterized in** that the X-profile (33) extends along the entire circumference

of the outer shell (13), that the X-profile (33) comprises a plurality of X-profile segments (33e) assembled into a ring, and that the respective X-profile segments (33e) are machined from a single metal piece.

5. A liquified gas storage tank (1) according to one of the preceding claims, **characterized in** that it is installed inside a hold space (16) defined partly by a ship hull structure and partly by a cover (17) arranged above the upper part of the liquified gas storage tank (1).

6. A liquified gas storage tank (1) according to claim 5, **characterized in** that the hold space (16) provides space for installing a hardening foam either on the outside of the outer shell (13) or on the structures comprising the hold space (16).

7. A method of manufacturing a liquified gas storage tank (1), the liquid gas storage tank (1) comprising an inner shell (11) and an outer shell (13) with an upper outer shell portion (13a) and a lower outer shell portion (13b), comprising

a) prefabricating an X-profile (33) comprising an upwardly extending shell profile (33c), a downwardly extending shell profile (33b), an upwardly extending interface profile (33d), and a downwardly extending interface profile (33a);

b) after step a), attaching

- the upwardly extending shell profile (33c) to an upper outer shell portion (13a) of an outer shell (13),
- the downwardly extending shell profile (33b) to a lower outer shell portion (13b) of the outer shell (13);
- the upwardly extending interface profile (33d) to an intermediate support (29) extending between the outer shell (13) and an inner shell (11); and attaching
- the downwardly extending interface profile (33a) to an upwardly extending support structure (27) configured to support the outer shell (13),

wherein the intermediate support (29) is vertically arranged and with the shape of a vertical cylinder.

8. A method according to claim 7, wherein step a) comprises milling respective X-profile segments (33e) of single pieces of metal.

Patentkrav

1. En flytende gass-lagringstank (1) omfattende
- et kurvet indre skall (11) og et kurvet ytre skall (13), og et isolerende rom (15) mellom det indre og ytre skallet,
- en oppover-ragende støttestruktur (27) innrettet til å støtte det indre og ytre skallet (11, 13), idet støttestrukturen (27) er koblet til det ytre skallet (13),

og ytterligere omfattende
- en mellomliggende støtte (29) som strekker seg gjennom det isolerende rommet (15), mellom det indre skallet (11) og det ytre skallet (13) for å støtte det indre skallet (11) inne i det ytre skallet (13),

hvorved lagringstanken (1) ytterligere omfatter en prefabrikkert X-profil (33) innlemmet som en del av det ytre skallet (13), idet X-profilen (33) omfatter en oppover-ragende skallprofil (33c) koblet til en øvre ytre skalldel (13a) av det ytre skallet (13), og en nedover-ragende skallprofil (33b) koblet til en nedre ytre skallprofil (13b) av det ytre skallet (13), og hvorved X-profilen (33) ytterligere omfatter en oppover-ragende grensesnittsprofil (33d) som kobler til den mellomliggende støtten (29) og en nedover-ragende grensesnittsprofil (33a) som kobler til støttestrukturen (27),
karakterisert ved at den mellomliggende støtten (29) er vertikalt anordnet og med formen av en vertikal sylinder.

2. En flytende gass-lagringstank (1) i samsvar med krav 1, **karakterisert ved** at den ytterligere omfatter en støtteprofil (31) med en oppover-ragende skallprofil (31a) som kobler til en øvre indre skalldel (11a) av det indre skallet (11), og en nedover-ragende skallprofil (31c) som kobler til en nedre indre skalldel (11b) av det indre skallet (11), og en nedover-ragende grensesnittsprofil (31b) som kobler til den mellomliggende støtten (29).

3. En flytende gass-lagringstank (1) i samsvar med krav 1 eller krav 2, **karakterisert ved** at den inneholder flytende hydrogen.

4. En flytende gass-lagringstank (1) i samsvar med et av de foregående kravene, **karakterisert ved** at X-profilen (33) strekker seg langs hele omkretsen

til det ytre skallet (13), at X-profilen (33) omfatter et flertall X-profilsegmenter (33e) sammensatt til en ring, og at de respektive X-profilsegmentene (33e) er maskinert fra et enkelt metallstykke.

5. En flytende gass-lagringstank (1) i samsvar med et av de foregående kravene, **karakterisert ved** at den er installert inne i et holderom (16) definert delvis av en skipsskrogsstruktur og delvis av et deksel (17) anordnet over den øvre delen av den flytende gass-lagringstanken (1).

6. En flytende gass-lagringstank (1) i samsvar med krav 5, **karakterisert ved** at holderommet (16) tilveiebringer rom for installering av et herdende skum enten på utsiden av det ytre skallet (13) eller på strukturene som omfatter holderommet (16).

7. En fremgangsmåte for tilvirkning av en flytende gass-lagringstank (1), der flytende gass-lagringstanken (1) omfatter et indre skall (11) og et ytre skall (13), med en øvre ytre skalldel (13a) og en nedre ytre skalldel (13b), omfattende

a) å prefabrikkere en X-profil (33) omfattende en oppover-ragende skallprofil (33c), en nedover-ragende skallprofil (33b), en oppover-ragende grensesnittsprofil (33d) og en nedover-ragende grensesnittsprofil (33a);

b) etter trinn a), å feste

- den oppover-ragende skallprofilen (33c) til en øvre ytre skalldel (13a) av et ytre skall (13),
- den nedover-ragende skallprofilen (33b) til en nedre ytre skalldel (13b) av det ytre skallet (13),
- den oppover-ragende grensesnittsprofilen (33d) til en mellomliggende støtte (29) som strekker seg mellom det ytre skallet (13) og et indre skall (11); og å feste
- den nedover-ragende grensesnittsprofilen (33a) til en oppover-ragende støttestruktur (27) innrettet til å støtte det ytre skallet (13),

hvorved den mellomliggende støtten (29) er vertikalt anordnet og har formen av en vertikal sylinder.

8. En fremgangsmåte i samsvar med krav 7, hvorved trinn a) omfatter å frese

respektive X-profilsegmenter (33e) av enkeltvise metallstykker.

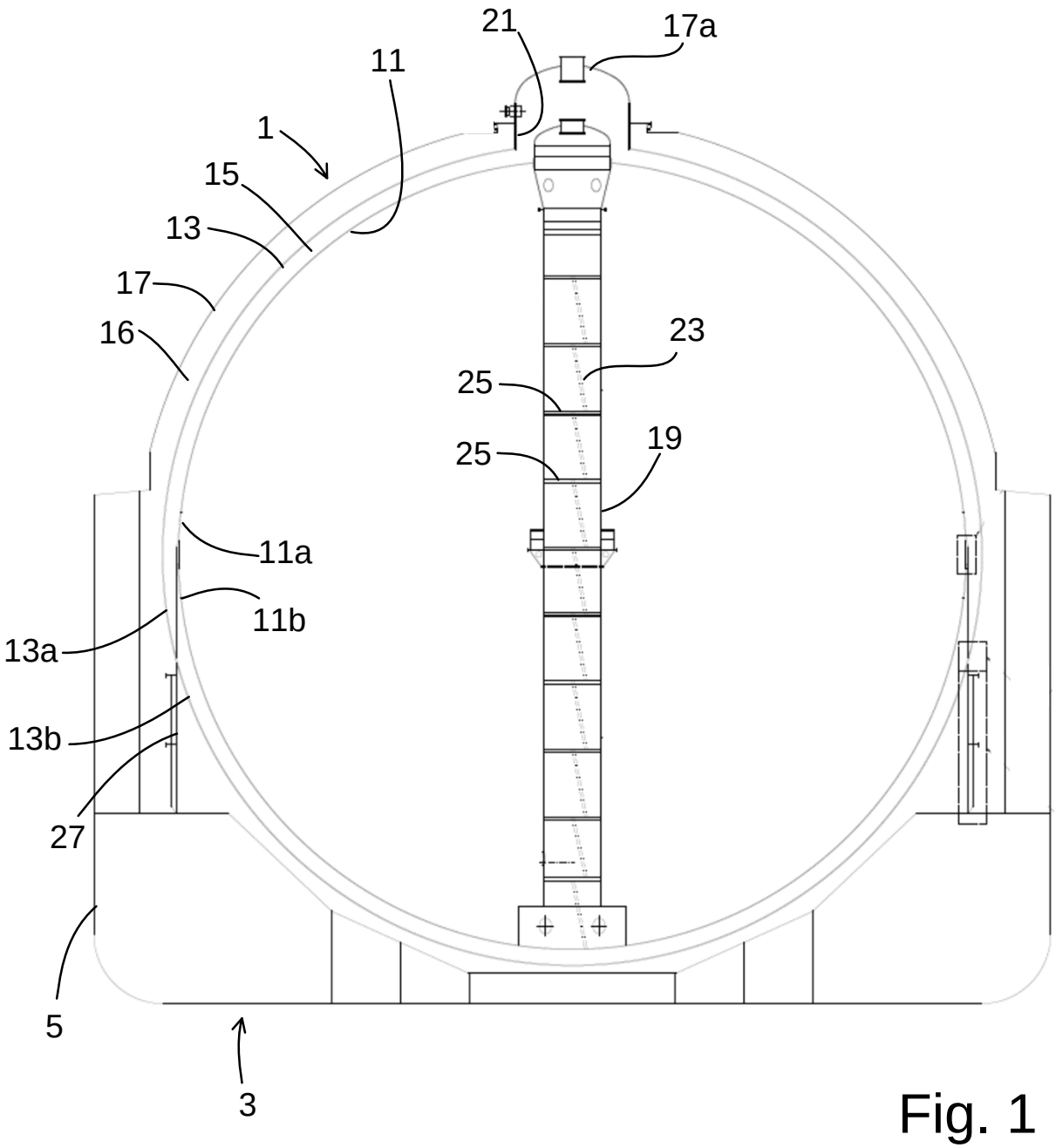


Fig. 1

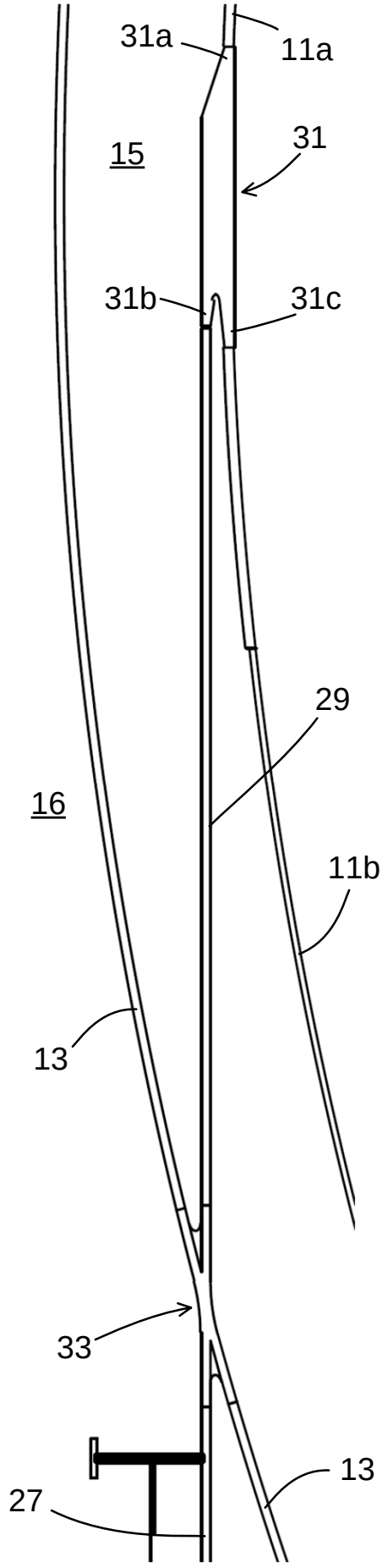

31a
11a
15
31
31b
31c
29
16
11b
13
33
13
27

Fig. 2

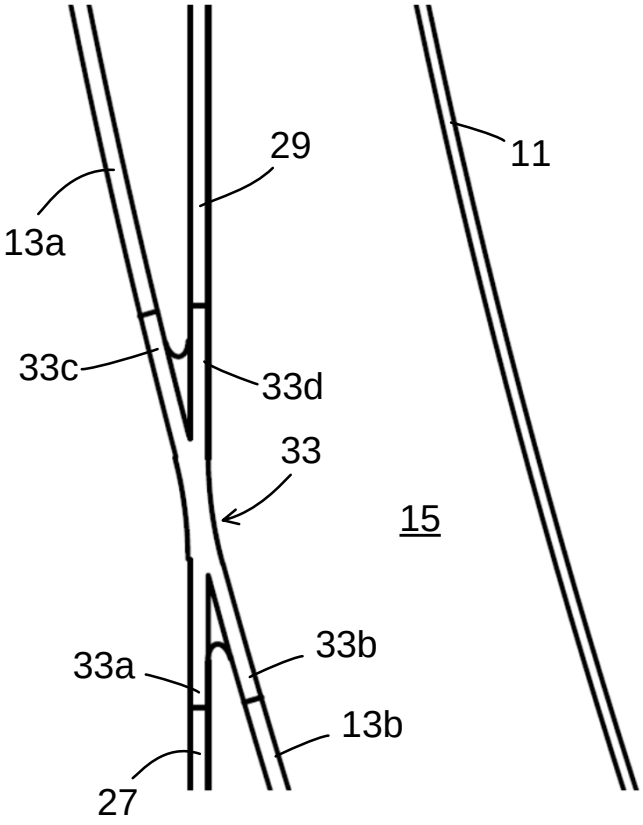

29
11
13a
33c
33d
33
15
33b
33a
13b
27

Fig. 3

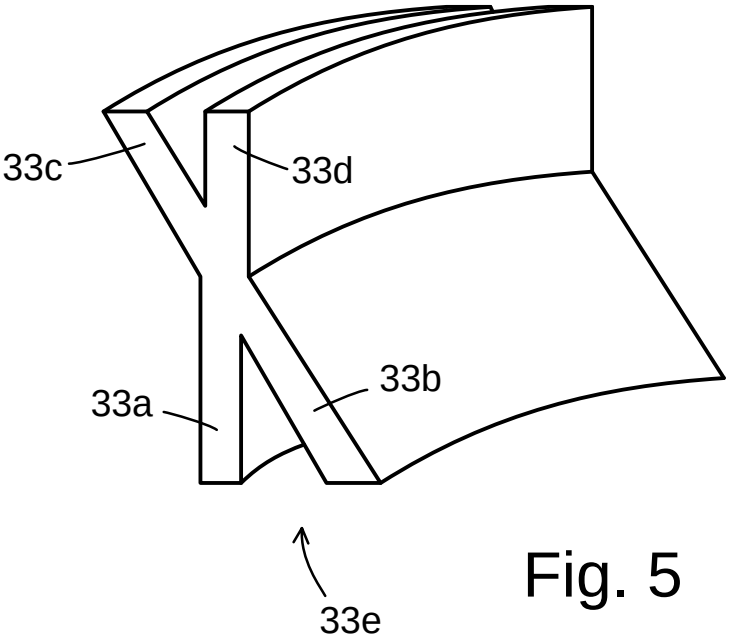


Fig. 5

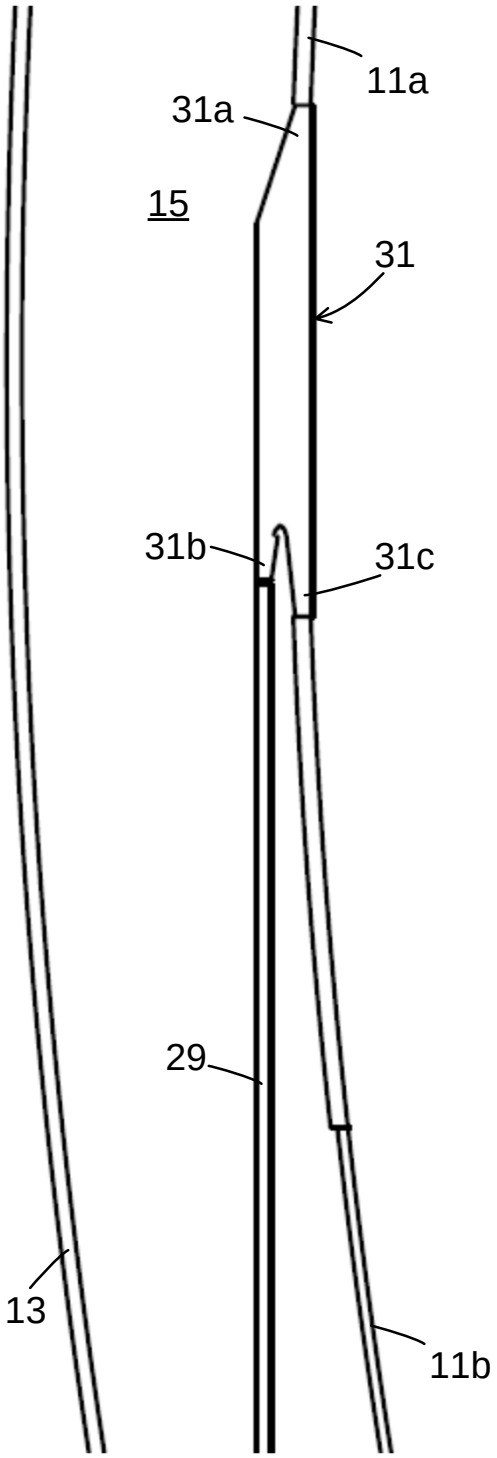


Fig. 4