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(54) **COMPOSITE HYDROGEN TANK FOR AN AIRCRAFT**

VERBUNDSTOFF-WASSERSTOFFTANK FÜR EIN FLUGZEUG

RÉSERVOIR D'HYDROGÈNE COMPOSITE POUR UN AÉRONEF

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Description

FIELD OF THE INVENTION

[0001] The present invention refers to a composite hydrogen tank for an aircraft designed to fulfill the debonding requirements specified for the certification of an aircraft.

BACKGROUND OF THE INVENTION

[0002] Current vessels for hydrogen are not designed for aircraft flying conditions and they are divided in two groups, gaseous and liquid hydrogen (GH2 and LH2): Tanks vessels GH2: They are built to store gas hydrogen and designed with a high thickness to support great pressures (~700 bar) mainly used in industries where vessel weight is not key.

[0003] Tanks vessels LH2: They are built to store liquid hydrogen and designed with small thicknesses as they do not support great pressures (~5 bar). They are mainly used in the aero spatial sector where weight is key for the launch vehicle.

[0004] In applications for aircrafts, the LH2 tank solution is the most suitable due to the weight condition, but in addition to the many challenges that LH2 tanks solve for launch vehicles, additional requirements must be solved to integrate LH2 tanks in aircrafts systems. In particular: Flight maneuvers: An aircraft has a larger range of maneuvers than a launch vehicle which mainly has accelerations in Z axis which could be reacted by the vehicle rings. For aircraft applications, an additional protection to the LH2 vessel is required to attach the tank to the aircraft and withstand flight loads.

[0005] Insulation: Due to different mission conditions, the dormancy time for an aircraft application compared to a launch vehicle is longer. This implies that the tank insulation requires additional complexity including vacuum in between the additional protection and the inner vessel, in contrast to the space application wherein vacuum is not required.

[0006] Pressure load: The use of flat panels as integrated elements of tanks vessels is subjected to pressure loads, which induce compression loads in the panel, presenting one of the worst cases for buckling conditions.

[0007] The manufacturing of a CFRP pressure vessel for H2 that has to contain different systems and structures (as anti-sloshing walls or pipes/sensors), will be provided with one or more bonding/co-bonding processes to form the final air-tight vessel. In this case, the airworthiness regulations requires considering the failure of such bonding. This bonding failure must not lead to a catastrophic event, and the continuation of the flight must be ensured.

[0008] In addition, as no rivets are allowed in the construction of a Hydrogen tight vessel (to avoid that the H2 escapes through the space between the bolt/fastener and the CFRP), specially when loaded, bonding or co-bonding process shall be used to join the different parts

needed for the complete vessel. In this case, debonding failures case must be considered.

[0009] US 2020/332960 A1 discloses a high pressure tank liner and method of manufacturing the same, where in the vicinity of an opening end of a first liner constituent member and a second liner constituent member made of a resin material, a flange portion is formed. After end surfaces of the opening end are abutted and joined to each other, the flange portion is removed in such a way that a part of a bottom portion remains. The remaining amount of protrusion is set such that the joint strength of a joint portion is not less than the tensile strength of the resin material or not less than the cohesion failure strength of the joint portion.

[0010] Therefore, there is a need for a composite hydrogen tank that secures the bondings, such that the requirements specified by the airworthiness regulations for the certification of the aircraft are met.

SUMMARY OF THE INVENTION

[0011] The present invention overcomes the above mentioned drawback by providing a composite hydrogen tank for an aircraft formed by the joint of parts that meets the debonding failures requirements for the aircraft certification.

[0012] The present invention refers to a composite hydrogen tank for an aircraft according to claim 1 that comprises first and second halves of a tank, each half having an elongated tubular shape with an open end and a joining area comprising the open end, at least one bonding layer laid on at least one joining area of one of the halves of the tank to perform their bonding, and a joint formed by the bonding of the first and second halves at their joining areas.

[0013] According to the invention, the joint further comprises at least one joining profile cured or cobonded at the joining area of at least one of the halves of the tank to reinforce their bonding.

[0014] Since hydrogen may escape through the space between the bolt/fastener and the CFRP parts, specially when loaded, no rivets are allowed in the construction of an hydrogen tank. In this context, the invention provides a tank that combines the bonding and the curing or cobonding of a joining profile that permits a safe joint of parts where debonding failures are avoided.

[0015] This way, the invention allows the manufacturing of an hydrogen tight vessel in separated parts that meets the airworthiness regulations, and thus can be included in the aircraft. The manufacturing of the vessel in separated parts are needed for the installation of pipes, walls, and any other components needed inside the vessel before closing tight the whole part.

DESCRIPTION OF THE FIGURES

[0016] To complete the description and in order to provide for a better understanding of the invention, a

set of drawings is provided. Said drawings form an integral part of the description and illustrate preferred embodiments of the invention. The drawings comprise the following figures.

Figure 1 shows a schematic view of a composite hydrogen tank according to an example not forming part of the present invention.

Figure 2 shows a schematic view of a composite hydrogen tank according to an example not forming part of the present invention.

Figure 3 shows a schematic view of a composite hydrogen tank according to an example not forming part of the present invention.

Figure 4 shows a schematic view of a composite hydrogen tank according to a preferred embodiment of the invention.

Figure 5 shows a schematic view of a composite hydrogen tank according to an example not forming part of the present invention.

Figure 6 shows a schematic view of a composite hydrogen tank according to an example not forming part of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0017] Figure 1 shows a composite hydrogen tank (1) for an aircraft that comprises:

- first and second halves (2, 3) of a tank, each half (2, 3) having an elongated tubular shape with an open end (2a, 3a) and a joining area (2b, 3b) comprising the open end (2a, 3a),
- at least one bonding layer (4) laid on at least one joining area (2b, 3b) of one of the halves of the tank (2, 3) to perform their bonding, and
- a joint (5) formed by the bonding of the first and second halves (2, 3) at their joining areas (2b, 3b),
- wherein the joint (5) further comprises at least one joining profile (6) cocured or cobonded at the joining area (2b, 3b) of at least one of the halves of the tank (2, 3) to reinforce their bonding.

[0018] In Figure 1, the joining profile (6) is cocured to the second half of the tank (3) and has a L-shaped configuration to receive attachments (7) at its web (6a). This mechanical attachment (7) will work only in the event of a disbanding.

[0019] In addition, the open end (2a, 3a) of the first half (2) of the tank (1) has a L-shaped configuration providing an easy attach to the profile web (6a).

[0020] Figure 2 shows a tank (1) wherein the joining profile (6) is cocured to each one of the halves of the tank

(2, 3), and wherein one of these joining profiles (6) protrudes from the open end (2a, 3a) of the half (2, 3) of the tank in which is cocured to provide an easy attach between the profiles (6). To reinforce this joint (5), attachments (7) are provided between the profiles (6).

[0021] Figure 3 shows a tank (1) in which the joining profile (6) has a I-shaped configuration, and is cobonded to the first and second halves of the tank (2, 3).

[0022] Figure 4 shows a tank (1), similar to the one shown in Figure 3, but comprising a pair of bonding layers (4', 4'') laid on the joining areas (2b, 3b) of both halves of the tank (2, 3), separated by a gap to resist potential de-bondings.

[0023] Figure 5 shows a tank (1) further comprising attachments (8) to join the at least one joining profile (6) to one of the halves of the tank (2, 3).

[0024] Figure 6 shows a tank (1) further comprising an extra profile (6') extended along the joining area (2b, 3b) of both the first and second halves of the tank (2, 3), and at least one extra bonding layer (10) laid between the open ends (2a, 3a) of the first and second halves of the tank (2, 3) and the extra profile (6') to reinforce the bonding of the halves (2, 3).

Claims

1. Composite hydrogen tank (1) for an aircraft, comprising:

- first and second halves (2, 3) of a tank, each half (2, 3) having an elongated tubular shape with an open end (2a, 3a) and a joining area (2b, 3b) comprising the open end (2a, 3a),
- at least one bonding layer (4) laid on at least one joining area (2b, 3b) of one of the halves of the tank (2, 3) to perform their bonding, and
- a joint (5) formed by the bonding of the first and second halves (2, 3) at their joining areas (2b, 3b),
- wherein the joint (5) further comprises at least one joining profile (6) cocured or cobonded at the joining area (2b, 3b) of at least one of the halves of the tank (2, 3) to reinforce their bonding,

characterized in that the composite hydrogen tank (1) comprises a pair of bonding layers (4', 4'') laid on at least one joining area (2b, 3b) of one of the halves of the tank (2, 3), separated by a gap to resist potential de-bondings.

2. Composite hydrogen tank (1) for an aircraft, according to claim 1, wherein the joining profile (6) is cocured to at least one of the halves of the tank (2, 3) and has a L-shaped, U-shaped or T-shaped configuration to receive attachments (7) at its web (6a).

3. Composite hydrogen tank (1) for an aircraft, according to claim 2, wherein the joining profile (6) is co-cured to one half of the tank (2, 3), and wherein the open end (2a, 3a) of the other half (2, 3) of the tank (1) has a L-shaped configuration to be easily attached to the profile web (6a). 5
4. Composite hydrogen tank (1) for an aircraft, according to claim 2, wherein one joining profile (6) is co-cured to each one of the halves of the tank (2, 3), and wherein one of these joining profiles (6) protrudes from the open end (2a, 3a) of the half (2, 3) of the tank in which is co-cured to provide an easy attach between the profiles (6). 10
5. Composite hydrogen tank (1) for an aircraft, according to any of claims 1 or 4, further comprising attachments (8) to join the at least one joining profile (6) to one of the halves of the tank (2, 3). 15
6. Composite hydrogen tank (1) for an aircraft, according to claim 1, further comprising an extra profile (6') extended along the joining area (2b, 3b) of both the first and second halves of the tank (2, 3), and at least one extra bonding layer (10) laid between the open ends (2a, 3a) of the first and second halves of the tank (2, 3) and the extra profile (6') to reinforce the bonding of the halves (2, 3). 20 25
7. Composite hydrogen tank (1) for an aircraft, according to claim 6, comprising a pair of extra bonding layers (10) laid along both extremes of the extra profile (6'). 30
8. Composite hydrogen tank (1) for an aircraft, according to any preceding claim, wherein one of the first and second halves (2, 3) has lower cross-sectional size than the other half (2, 3) to allow its introduction and overlap at their joining areas (2b, 3b). 35 40

Patentansprüche

1. Verbundstoff-Wasserstofftank (1) für ein Flugzeug, mit: 45
 - einer ersten und einer zweiten Tankhälfte (2, 3), wobei jede Hälfte (2, 3) eine längliche Rohrform mit einem offenen Ende (2a, 3a) und einem Fügebereich (2b, 3b) hat, der das offene Ende (2a, 3a) umfasst, 50
 - mindestens einer Bindungsschicht (4), die auf mindestens einem Fügebereich (2b, 3b) einer der Hälften des Tanks (2, 3) aufgebracht ist, um deren Bindung durchzuführen, und
 - einem Anschlussstück (5), das durch die Bindung der ersten und zweiten Hälfte (2, 3) an ihren Fügebereichen (2b, 3b) ausgebildet wird, 55

- wobei das Anschlussstück (5) ferner mindestens ein Fügeprofil (6) hat, das an dem Fügebereich (2b, 3b) mindestens einer der Hälften des Tanks (2, 3) mitgehärtet oder mitverbunden ist, um deren Bindung zu verstärken, **dadurch gekennzeichnet, dass** der Verbundstoff-Wasserstofftank (1) ein Paar von Bindungsschichten (4', 4'') hat, die auf mindestens einem Fügebereich (2b, 3b) einer der Hälften des Tanks (2, 3) aufgebracht sind und durch einen Spalt voneinander getrennt sind, um einer möglichen Trennung der Bindung entgegenzuwirken.

2. Verbundstoff-Wasserstofftank (1) für ein Flugzeug gemäß Anspruch 1, wobei das Fügeprofil (6) mit mindestens einer der Hälften des Tanks (2, 3) mitgehärtet ist und eine L-förmige, U-förmige oder T-förmige Konfiguration konfiguriert ist, um Befestigungen (7) an seinem Steg (6a) anzubringen.
3. Verbundstoff-Wasserstofftank (1) für ein Flugzeug gemäß Anspruch 2, wobei das Fügeprofil (6) mit einer Hälfte des Tanks (2, 3) mitgehärtet ist und wobei das offene Ende (2a, 3a) der anderen Hälfte (2, 3) des Tanks (1) eine L-förmige Konfiguration aufweist, um einfach an dem Steg (6a) des Profils angebracht werden zu können.
4. Verbundstoff-Wasserstofftank (1) für ein Flugzeug gemäß Anspruch 2, wobei ein Fügeprofil (6) mit jeder der Hälften des Tanks (2, 3) mitgehärtet ist und wobei eines dieser Fügeprofile (6) aus dem offenen Ende (2a, 3a) der Hälfte (2, 3) des Tanks, in der es mitgehärtet ist, vorragt, um eine einfache Anbringung zwischen den Profilen (6) zu ermöglichen.
5. Verbundstoff-Wasserstofftank (1) für ein Flugzeug gemäß einem der Ansprüche 1 oder 4, der ferner Befestigungselemente (8) hat, um das mindestens ein Fügeprofil (6) mit einer der Hälften des Tanks (2, 3) zusammenzufügen.
6. Verbundstoff-Wasserstofftank (1) für ein Flugzeug gemäß Anspruch 1, der ferner ein zusätzliches Profil (6') hat, das sich entlang des Fügebereichs (2b, 3b) sowohl der ersten als auch der zweiten Hälfte des Tanks (2, 3) erstreckt, und mindestens eine zusätzliche Bindungsschicht (10) aufweist, die zwischen den offenen Enden (2a, 3a) der ersten und zweiten Hälfte des Tanks (2, 3) und dem zusätzlichen Profil (6') angeordnet ist, um die Verbindung der Hälften (2, 3) zu verstärken.
7. Verbundstoff-Wasserstofftank (1) für ein Flugzeug gemäß Anspruch 6, der ein Paar zusätzlicher Bindungsschichten (10) hat, die entlang beider Extrempunkte des zusätzlichen Profils (6') angeordnet sind.

8. Verbundstoff-Wasserstofftank (1) für ein Flugzeug gemäß einem der vorangehenden Ansprüche, wobei eine der ersten und zweiten Hälften (2, 3) eine geringere Querschnittsgröße als die andere Hälfte (2, 3) aufweist, um ihr Einführen und Überlappen an ihren Fügebereichen (2b, 3b) zu ermöglichen.

Revendications

1. Réservoir (1) d'hydrogène composite destiné à un aéronef, comprenant :

- des première et seconde moitiés (2, 3) d'un réservoir, chaque moitié (2, 3) présentant une forme tubulaire allongée avec une extrémité ouverte (2a, 3a) et une zone de jonction (2b, 3b) comprenant l'extrémité ouverte (2a, 3a),
- au moins une couche de liaison (4) déposée sur au moins une zone de jonction (2b, 3b) de l'une des moitiés (2, 3) du réservoir pour effectuer leur liaison, et
- un raccord (5) formé par la liaison des première et seconde moitiés (2, 3) au niveau de leurs zones de jonction (2b, 3b),
- dans lequel le raccord (5) comprend en outre au moins un profilé de jonction (6) co-durci ou co-lié au niveau de la zone de jonction (2b, 3b) d'au moins l'une des moitiés (2, 3) du réservoir pour renforcer leur liaison,

caractérisé en ce que le réservoir (1) d'hydrogène composite comprend une paire de couches de liaison (4', 4'') déposées sur au moins une zone de jonction (2b, 3b) de l'une des moitiés (2, 3) du réservoir, séparées par un espace afin de résister aux décohésions potentielles.

2. Réservoir (1) d'hydrogène composite destiné à un aéronef, selon la revendication 1, dans lequel le profilé de jonction (6) est co-durci sur au moins l'une des moitiés (2, 3) du réservoir et présente une configuration en forme de L, en forme de U ou en forme de T pour recevoir des attaches (7) au niveau de son âme (6a).
3. Réservoir (1) d'hydrogène composite destiné à un aéronef, selon la revendication 2, dans lequel le profilé de jonction (6) est co-durci sur une moitié (2, 3) du réservoir, et dans lequel l'extrémité ouverte (2a, 3a) de l'autre moitié (2, 3) du réservoir (1) présente une configuration en forme de L pour être facilement attachée à l'âme (6a) de profilé.
4. Réservoir (1) d'hydrogène composite destiné à un aéronef, selon la revendication 2, dans lequel un profilé de jonction (6) est co-durci sur chacune des moitiés (2, 3) du réservoir, et dans lequel l'un de ces

profilés de jonction (6) fait saillie depuis l'extrémité ouverte (2a, 3a) de la moitié (2, 3) du réservoir dans laquelle il est co-durci pour permettre une attache facile entre les profilés (6).

5. Réservoir (1) d'hydrogène composite destiné à un aéronef, selon l'une quelconque des revendications 1 ou 4, comprenant en outre des attaches (8) pour joindre le au moins un profilé de jonction (6) à l'une des moitiés (2, 3) du réservoir.
6. Réservoir (1) d'hydrogène composite destiné à un aéronef, selon la revendication 1, comprenant en outre un profilé supplémentaire (6') étendu le long de la zone de jonction (2b, 3b) des première et seconde moitiés (2, 3) du réservoir, et au moins une couche de liaison supplémentaire (10) déposée entre les extrémités ouvertes (2a, 3a) des première et seconde moitiés du réservoir (2, 3) et le profilé supplémentaire (6') pour renforcer la liaison des moitiés (2, 3).
7. Réservoir (1) d'hydrogène composite destiné à un aéronef, selon la revendication 6, comprenant une paire de couches de liaison supplémentaires (10) déposées le long des deux extrémités du profilé supplémentaire (6').
8. Réservoir (1) d'hydrogène composite destiné à un aéronef, selon une quelconque revendication précédente, dans lequel l'une des première et seconde moitiés (2, 3) présente une taille en coupe transversale plus petite que celle de l'autre moitié (2, 3) pour permettre son introduction et son chevauchement au niveau de leurs zones de jonction (2b, 3b).

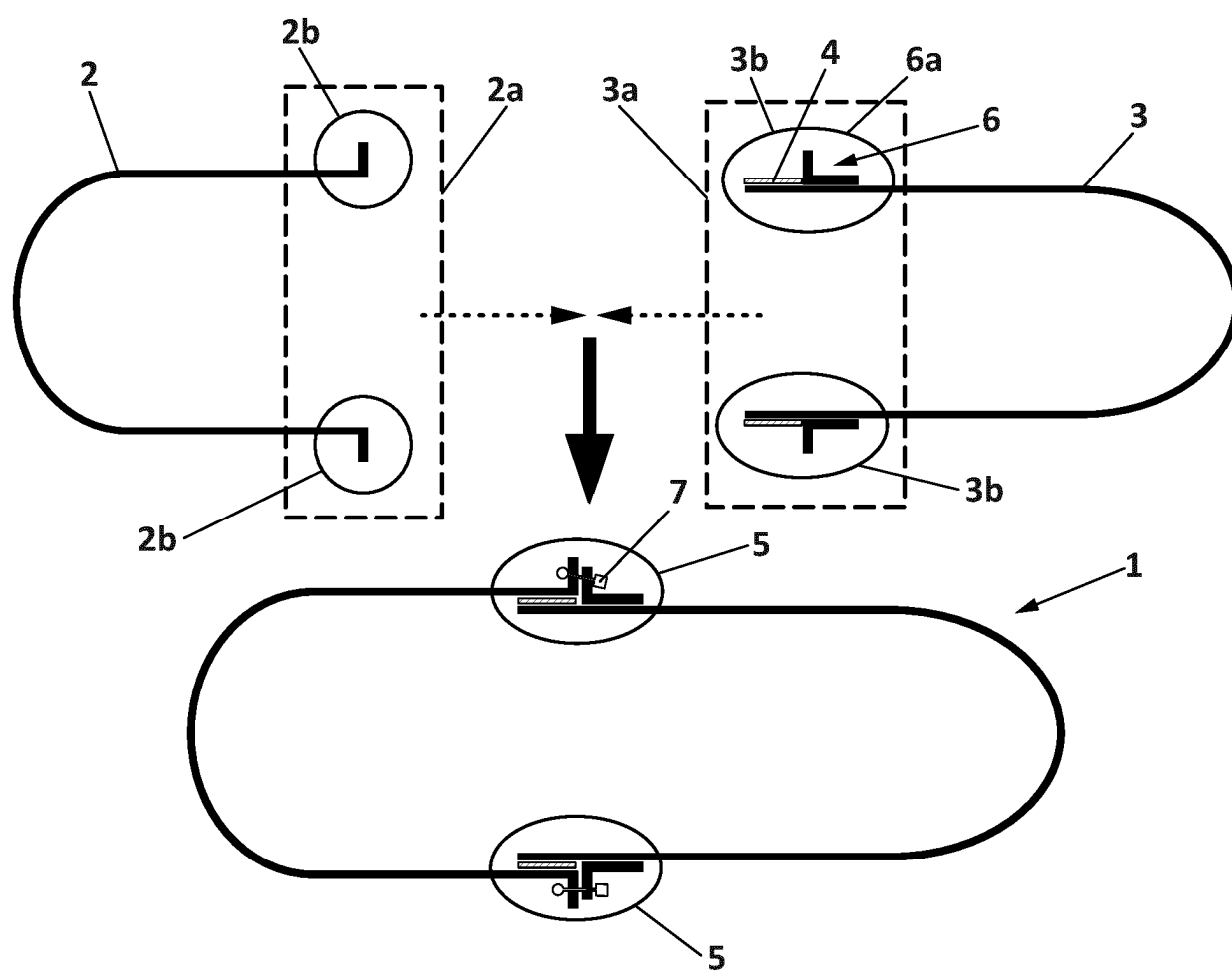


FIG. 1

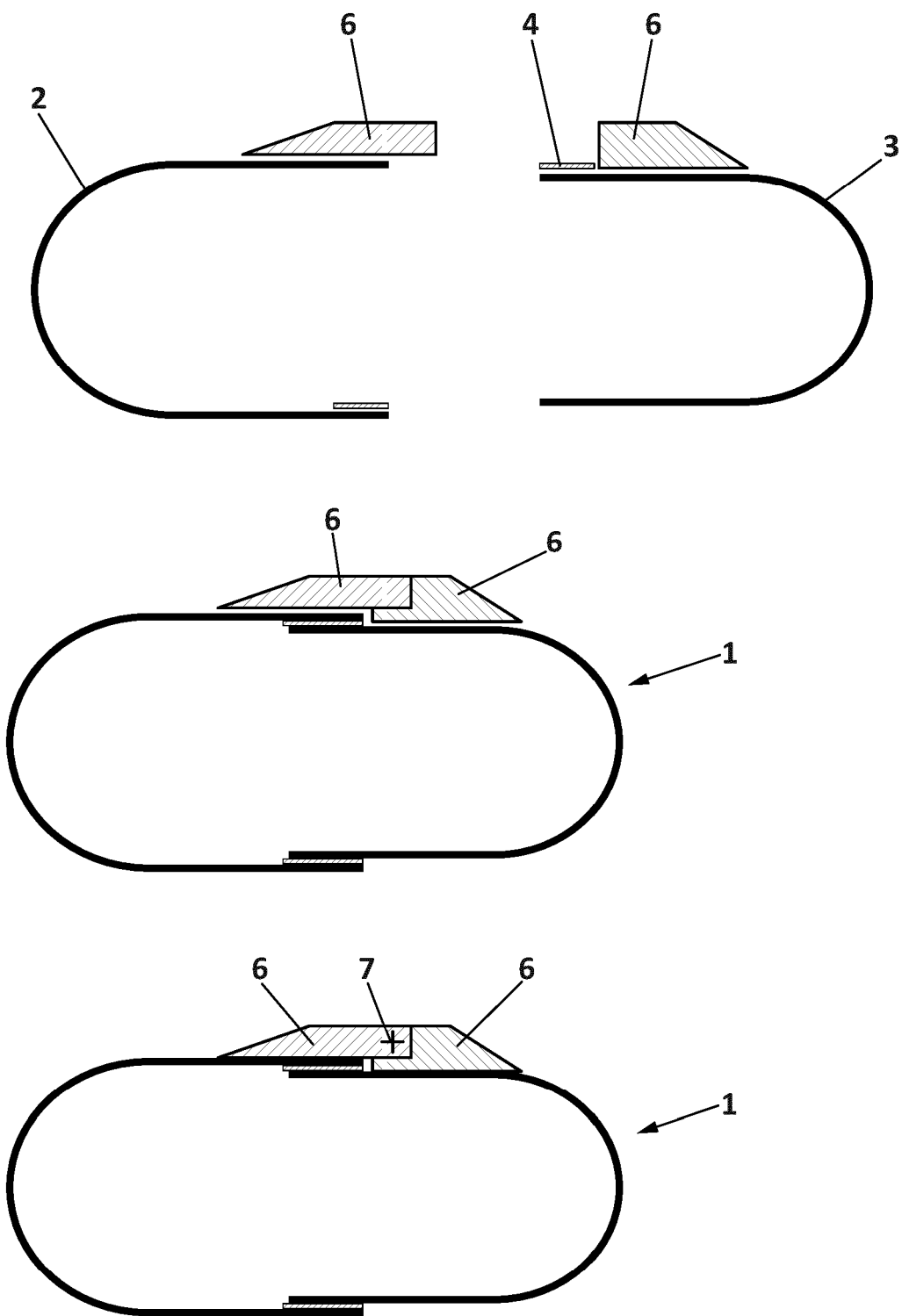


FIG. 2

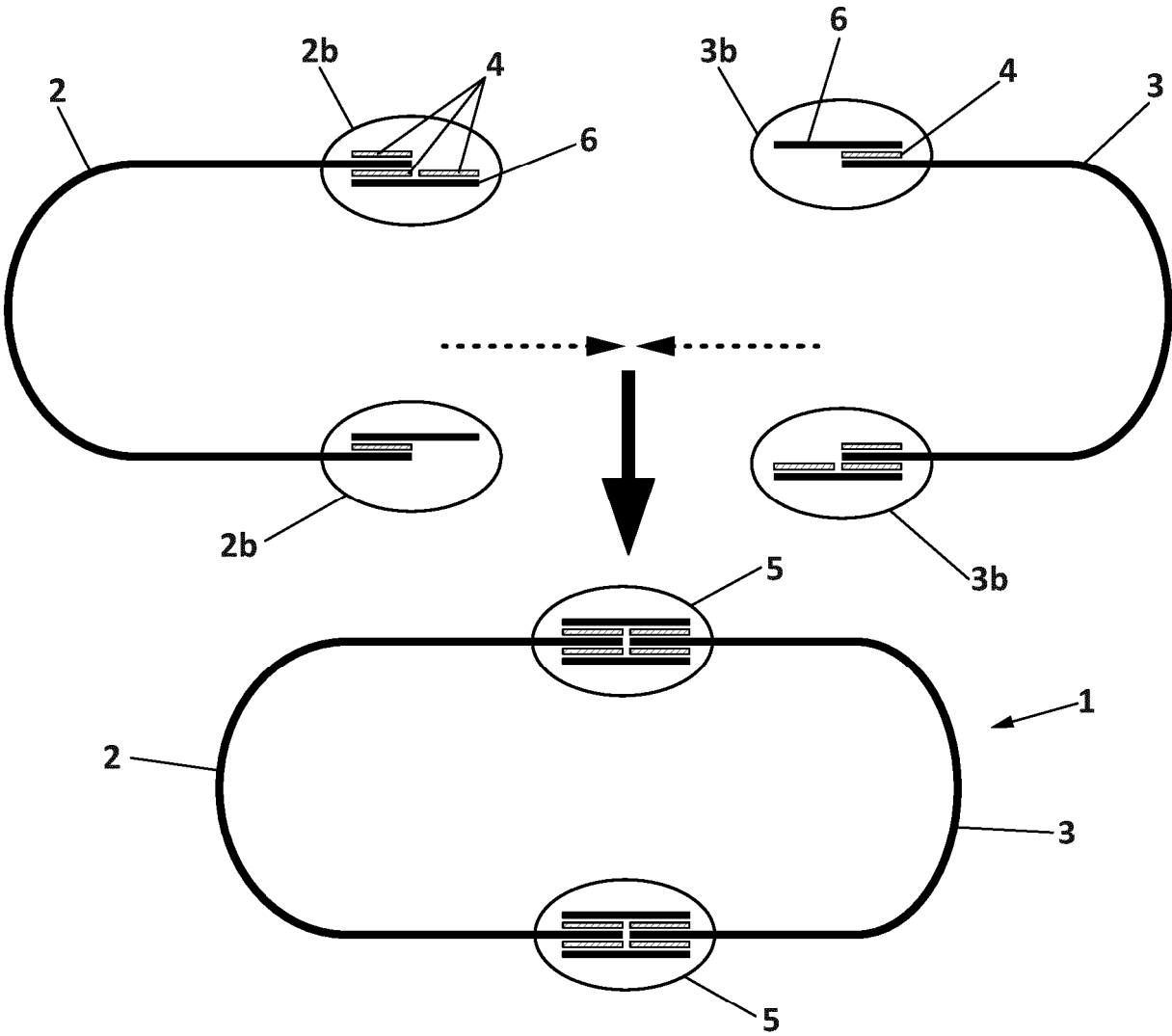


FIG. 3

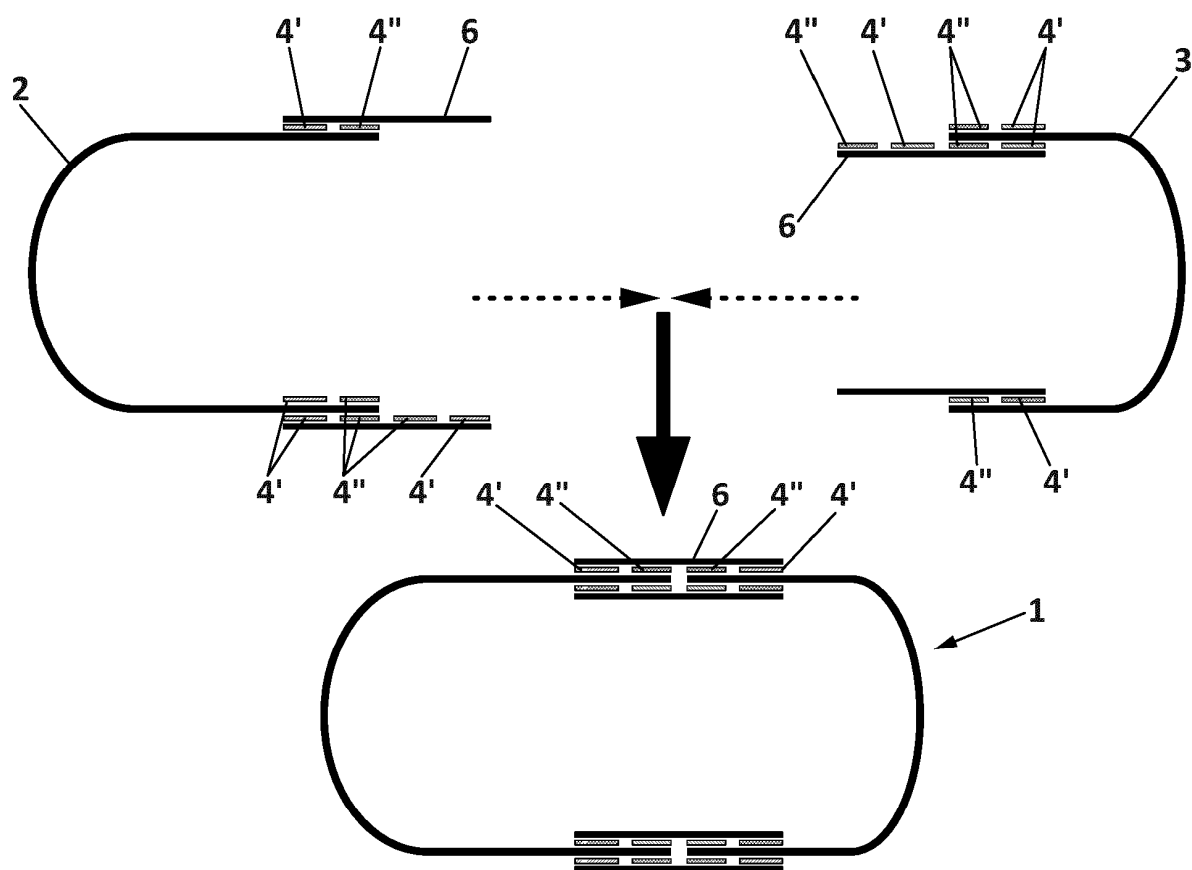


FIG. 4

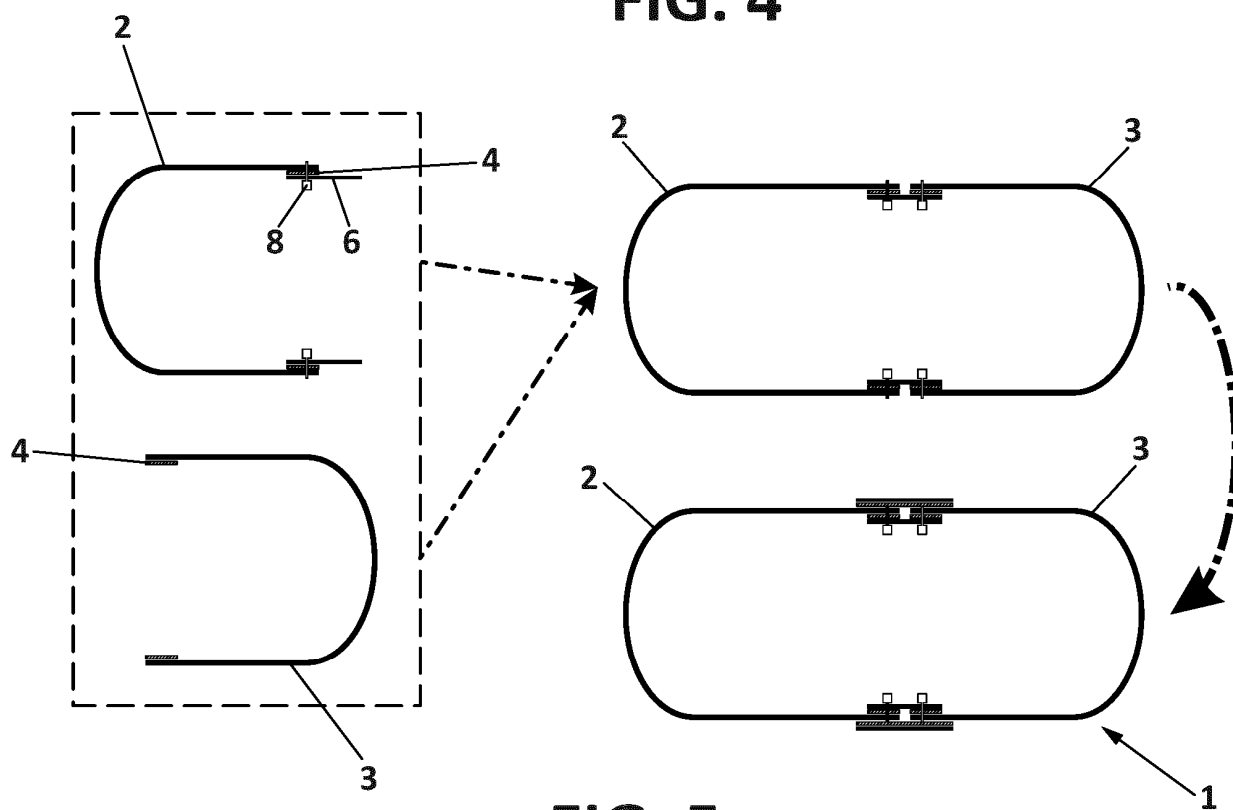


FIG. 5

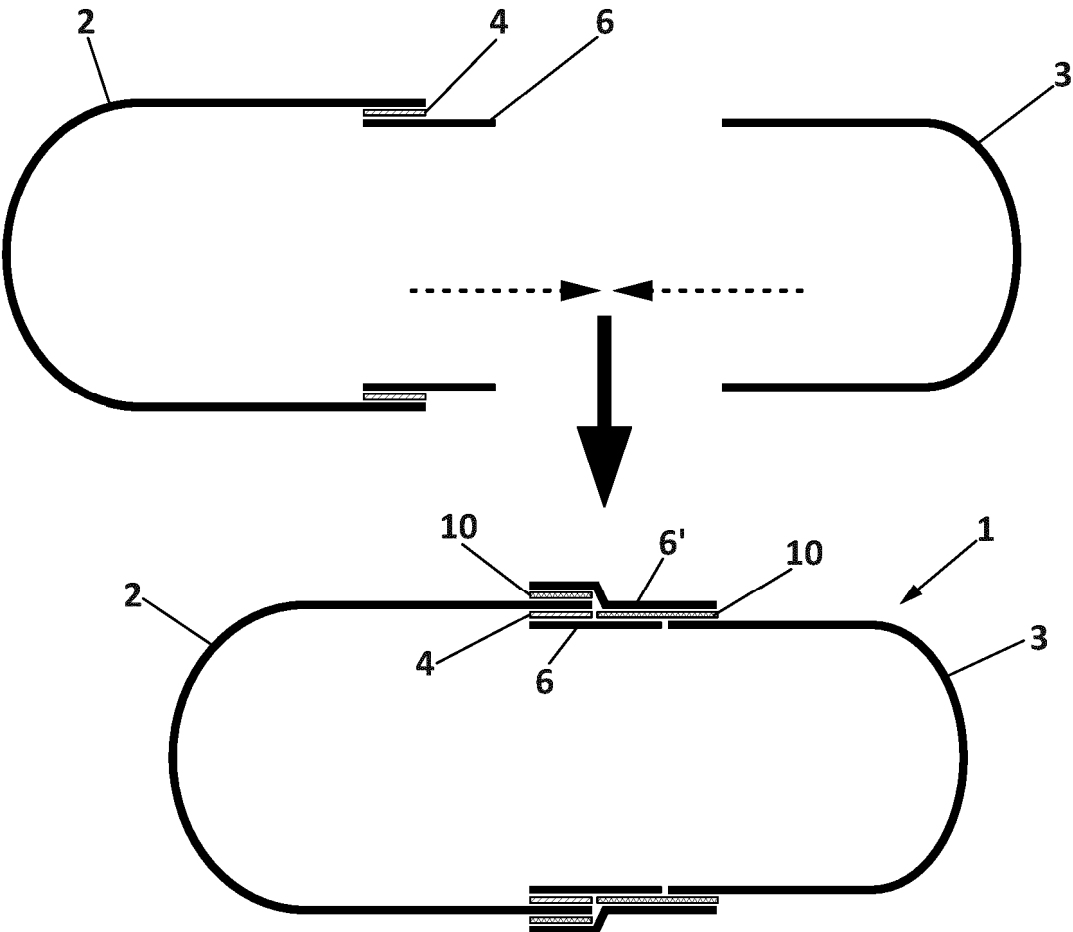


FIG. 6

REFERENCES CITED IN THE DESCRIPTION

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