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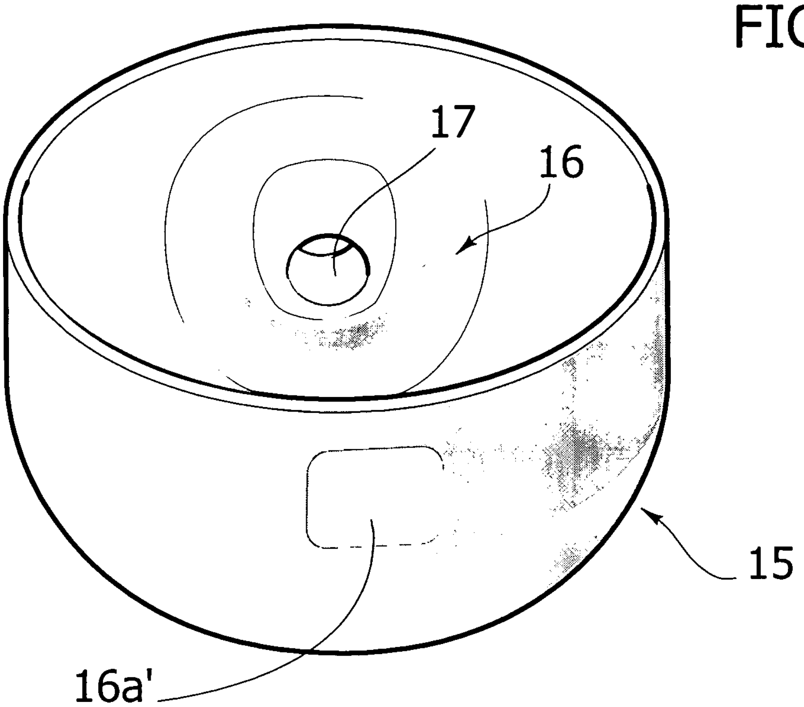
(54) **Tank for storing fluids at high pressures, in particular a gas for fuelling a motor vehicle engine, and manufacturing method thereof**

(57) A tank for storing a fluid at high pressure comprises a body (12) made of high-carbon steel or high-strength steel, to which a valve is rigidly fixed. The body (12) is formed in a single piece and comprises a terminal region (15) equipped with portions with thickened walls (16), which are arranged with central symmetry with respect to an axis (X) of the body (12). Made in at least one of the portions (16) is a through opening (17) to enable fixing thereto of the valve.

FIG. 3



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Description

[0001] The present invention relates to tanks for storing fluids at operating pressures higher than 100 bar, such as gas for fuelling a motor-vehicle engine, and to a method for the production of tanks of the type referred to.

[0002] Tanks of the type referred to comprise a body defining a hermetic chamber for containing the pressurized fluid. Rigidly associated to said body is at least one valve, suitable for enabling both charging of the aforesaid chamber with the fluid in order to fill the tank, and drawing-off of the fluid from the tank to enable its use. Said tanks find application in various sectors, amongst which of particular importance is the automobile sector, for the purpose of storage, at pressures in the region of 200-300 bar, of methane gas or hydrogen that is to fuel the internal-combustion engine of a vehicle.

[0003] The bodies of high-pressure gas tanks currently used in the automobile sector are made of steel on account of the relatively contained cost of said material and its solidity. In this regard, it should be pointed out that there exist also other types of cylinders that can be used as high-pressure gas tanks, such as ones made of composite material, but their very high cost prevents diffusion thereof in the automobile sector.

[0004] The steels used for the construction of the bodies of pressurized-gas tanks referred to are high-carbon steels in so far as they are the only ones suitable for guaranteeing the necessary safety in terms of strength. In such a perspective, the steel "34CrMo4" is universally adopted by manufacturers of cylinders used as high-pressure tanks in the automobile sector. Lowalloy steels or low-carbon steels are not instead deemed suitable for application in the case of high gas pressures, as in automobile use, on account of the low mechanical characteristics.

[0005] The bodies of high-pressure tanks of a known type are produced in a single piece made of high-alloy steel, with techniques characterized by the absence of any welding process. For said purpose, the body of the tank is built starting from a billet or a thick plate, using hot-pressing techniques, to form a hollow body with an end that must be closed. In some cases, the body of the tank is obtained starting from a tube, in which case both of its ends must be closed. Closing of the end of the body (in the case of a mechanical process starting from a billet or a thick plate) or of both of its ends (in the case of a mechanical process starting from a tube) is obtained via fluoforming, which consists in progressive hot deformation so as to bring up together the areas to be closed.

[0006] With reference to the automobile sector, a very important problem is linked to the encumbrance of the tanks or cylinders of the type referred to. It is evident in fact how the volume occupied by the tank assumes a fundamental role since, the greater the quantity of gas that can be stored therein, the greater the autonomy of the respective vehicle.

[0007] In the case of after-sales installation, i.e., installation on models of motor vehicles for which gas-fuelled propulsion was not originally envisaged, the arrangement of the tank occurs almost always in the boot compartment. In the case of models of motor vehicles designed originally for gas-fuelled propulsion, the tank is instead housed under the floor panel of the vehicle. In both of the aforementioned cases, the exploitation of space is vital, in so far as the space exploited for housing the gas tank must be subtracted from the passenger compartment or the luggage compartment of the vehicle. In this regard, it should also be considered that natural gas, compressed at a pressure of approximately 200 bar and at an ambient temperature of 25°C as for use in the automobile sector requires a storage volume of up to three times higher than that of petrol, given the same distance covered by the vehicle.

[0008] Other problems regarding high-pressure gas tanks according to the current state of the art are linked to constraints of a normative type, which have an adverse effect on the useful dimensions of the tanks. In said perspective, once again with reference to the automobile sector, the area of attachment of the valve to the body of the tank is universally deemed a weak point or in any case a point to be protected with particular care. For this reason, appropriate standards prescribe a minimum safety distance between the valve and the perimeter of the vehicle, understood as the external side panel or any other part of the body or coachwork subject to impact in the case of accidents (in Italy, for example, the distance in question is fixed at 150 mm). The aforesaid normative constraints evidently reduce the lay-out available on the vehicle for housing the tank, with a consequent loss of potential storage capacity of the pressurized fuel.

[0009] The aim of the present invention is to overcome one or more of the drawbacks referred to above, and in particular to:

- render simpler, and more rapid and economically advantageous the construction of gas tanks for operating at pressures higher than 100 bar, in particular comprised between approximately 200 bar and 300 bar, at the same time guaranteeing the necessary mechanical sturdiness thereof; and
- reduce the current critical aspects of housing typical of the tanks according to the known art, guaranteeing at the same time the necessary degree of safety.

[0010] The above and other aims are achieved, according to the invention, by a tank for storing a fluid for supplying a motor-vehicle engine at operating pressures higher than 100 bar, in particular comprised between approximately 200 and 300 bar, having the characteristics of Claim 1.

[0011] Likewise, the aforesaid aims are achieved according to the invention by a method for the fabrication of a tank for storing a fluid at operating pressures higher than 100 bar, in particular a gas for fuelling a motor-vehicle engine, having the characteristics of Claim 11.

[0012] Preferred characteristics of the tank and of the method according to the invention are indicated in the annexed claims, which are to be understood as forming an integral part of the present description.

[0013] Further purposes, characteristics and advantages of the present invention will emerge clearly from the ensuing detailed description and from the annexed plate of drawings, which are provided purely by way of explanatory and non-limiting example and in which:

- Figure 1 is a perspective view of a high-pressure gas tank of a known type;
- Figure 2 is a perspective view of a high-pressure gas tank according to the invention;
- Figure 3 is a perspective view of a cross section of the tank of Figure 2;
- Figure 4 is a top-plan view of the cross section of Figure 3;
- Figure 5 is a cross-sectional view according to the line V-V of Figure 4;
- Figure 6 is a cross-sectional view according to the line VI-VI of Figure 5;
- Figures 7-12 are schematic representations illustrating the steps of an advantageous method for producing a tank according to the invention; and
- Figures 13A and 13B are two schematic plan views of a tank according to the invention and a tank according to the known art, respectively, in similar positions of installation.

[0014] In Figure 1, the reference number 1 designates as a whole a cylinder of a known type for storing a fluid at high pressure. In the case exemplified, the cylinder 1 is of the type commonly used as fuel tank of a motor vehicle for containing methane gas at a pressure ranging between approximately 200 bar and approximately 300 bar, necessary for supplying an internal-combustion engine.

[0015] The cylinder 1 has a body 2 having a bottom portion 3, an intermediate portion 4, and a head portion 5. The bottom portion 3 has a substantially flattened shape, the intermediate portion 4 has a generally hollow cylindrical shape, and the head portion 5 has a substantially hemispherical or cap-like shape.

[0016] The shape illustrated in Figure 1 is the one typical of the case where the body 2 is obtained in a single piece, via hot pressing of a steel billet or a thick steel plate, to form first of all the portions 3 and 4. The portion 5 is then obtained via fluoforming by deforming an end part of the intermediate portion 4. Alternatively, the intermediate portion 4 of the body 2 can be obtained starting from a tube, in which case both of the ends of the latter are shaped like a hemispherical cap via fluoforming.

[0017] The reference number 6 designates a valve, made in a way in itself known and provided to enable both charging of the cylinder 1 with methane gas, in the case of refuelling, and drawing of the gas from the cylinder in order to supply the engine of the motor vehicle. For this purpose, in use, the valve 6 is connected to suitable pipes for charging and drawing-off of the gas (not represented). In order to anchor the valve 6 to the body 2, a threaded part of the former is screwed in a through hole provided with internal screw on the top of the head portion 5.

[0018] In the type of embodiment illustrated in Figure 1, which is the one universally used in the case of cylinders made of steel for automobile purposes, the valve 6 projects from the body 2, in a position aligned with the axis of the latter. Said arrangement derives from the need to position the valve 6 in a point where the thickness of the body 2 is large, to be able to provide therein a sufficiently long threaded through hole such as to guarantee a secure anchorage of the valve 6. The process of fluoforming used for providing the head part 5 enables a sufficiently thick area of anchorage of the valve 6 for said purpose to be obtained.

[0019] It should be noted that the geometry and technique of construction of the tanks as identified above with reference to Figure 1 have remained substantially the same as the ones used for cylinders for containing technical gases employed prevalently in static uses, for which there do not exist critical aspects of encumbrance.

[0020] Such an embodiment presents the drawback that, on account of said technique of formation of the body 2, the valve 6 can be located only in a position corresponding to the top of the portion 5, to project from the latter. This has adverse effects on the overall dimensions of the cylinder 1 since the valve 6 must, for normative reasons, be kept at a certain distance from possible surfaces of impact. Consequently, the useful space that can be occupied by the body 2 is smaller, a fact that jeopardizes its capacity for storage of gas.

[0021] In accordance with an important aspect of the invention, the degree of safety and the storage capacity of the tank are increased by a particular modelling of the body of the cylinder, and in particular of one of its ends, in order to make available the respective valve in a safer or more protected position. As will emerge clearly from what follows, unlike the prior art, the end of the body of the cylinder to which the respective valve is fixed is not modelled via fluoforming.

[0022] For this purpose, Figures 2 to 6 represent a possible embodiment of a tank for storing fluids at operating pressures higher than 100 bar according to the present invention, said body being formed starting from a single piece, and being provided, in a position corresponding to a terminal region thereof - herein conventionally defined as "head region" -, with portions with thickened walls arranged with central symmetry with respect to the axis of the body, made in at least one of which is the hole in which the valve is fixed.

[0023] In the case exemplified in Figures 2 and 3, the tank according to the invention, designated as a whole by 11, has a body 12, in which an intermediate hollow region, designated by 14, and two terminal regions 13 and 15 are identified, which form the bottom and the head of the body 12, respectively. The intermediate region 14 is substantially cylindrical in shape, whilst the bottom terminal region 13 is as a whole cup-shaped; in particular, it has the shape of a hemispherical cap. The head region 15 has, instead, a more flattened configuration. The body 12 is made of hardened and tempered steels with high equivalent carbon content having ultimate strengths comprised between 800 and 1200 MPa (such as, for instance chromium-manganese or chromium-molybdenum steels, or high-strength steels, for example, 34CrMo4).

[0024] The valve 6 is fixed to the head terminal region 15 in a lateral position, said possibility of positioning being allowed on account of a particular conformation of the region itself.

[0025] Visible in Figure 3 is the internal part of just the terminal region 15, and represented in Figures 4, 5 and 6 are cross-sectional views of the same region, respectively according to three different mutually orthogonal planes. It should be noted that in said figures, for greater clarity, the representation of the valve 6 has been omitted. As emerges from said figures, in a position corresponding to side areas of the generally flattened cap that forms the terminal region 15, two localized portions with thickened walls are defined, designated by 16. The portions 16 are of dimensions such as to enable formation of an internal thread 17, or other type of through hole, in the desired position and of the desired length. Screwed into said hole is the threaded fixing part of the valve 6 of Figure 2, the remaining connection part of the valve remaining, instead, on the outside of the body 12.

[0026] For the purposes of the present description, in the thickened portions 16 three distinct areas can be identified. A first area 16a defines a substantially plane seat, which is made in a position corresponding to the hole 17 and has maximum thickness, with reference to a direction orthogonal to the central axis X of the body 12. A second area 16b defines a first area of radiusing around the aforesaid first area 16a, and a third area 16c defines a second area of radiusing around the aforesaid first and second areas 16a, 16b. The area 16c extends, on one side, towards the intermediate region 14 and, on the opposite side, towards the end of the terminal region 15, radiusing thereto in a continuous way. The first and second radiusing areas, respectively of the second and third areas 16b, 16c, have curvatures of opposite sign.

[0027] Furthermore, to obtain a resting seat for the valve 6 and facilitate fixing thereof on the body 12, the external side of the latter has, in a position corresponding to the first area 16a, a corresponding plane external region 16a'.

[0028] The conformation of the portions 16 described above is specific for the embodiment illustrated. However, in the scope of the present invention is included the formation of thickened portions 16 of another kind, having the characteristics specified in Claim 1.

[0029] As illustrated in Figures 5 and 6, the aforesaid first, second and third areas 16a, 16b and 16c have characteristic dimensions that define globally a specific geometry thereof. Said dimensions are listed hereinafter:

- L1: minimum side of the first area;
- A: width of a front projection of the thickened portion;
- B: height of a front projection of the thickened portion;
- R1: first radius of radiusing of the second area;
- R2: second radius of radiusing of the third area.

[0030] The experiments conducted by the present applicant on the cylinders of the embodiment described have revealed that the particular conformation of the portions 16 has led to a considerable strengthening of the tank according to the present invention with respect to the tanks of a conventional type, likewise enabling a secure fixing of the valve in all the conditions of use. An optimal conformation of the portions with thickened walls is identified by the relations that determine the value of the dimensions listed above, depending upon some dimensions of the body 12, so as to define for all the types of tanks in production, which are distinguished for volumetric capacity, the specific geometry of the portions 16 that guarantees the maximum strength, as found in the experimental cases.

[0031] With reference to the symbols of the dimensions given above, the preferred relations are the following:

A has a value comprised between approximately 0.45 and 0.51 of D, preferably 0.48 of D;
B has a value comprised between approximately 0.4 and 0.5 of D, preferably from 0.45 to 0.48 of D;
R1 has a value comprised between approximately 0.1 and 0.2 of D, preferably 0.13 of D;
R2 is greater than or equal to 10 mm, preferably greater than or equal to 15 mm,
D being the diameter of the tank.

[0032] The minimum side of the first area 16a must be greater than the diameter of the hole 17, preferably at least approximately 7% - 8% greater than the aforesaid diameter. In the case where, for example, the hole 17 has a diameter of 26 mm, the minimum side will be approximately 28 mm.

[0033] The body 12 of the tank or cylinder according to the present invention can be obtained in a simple and fast way via pressing from a steel billet of the type previously referred to, in so far as said technology is well suited to the complexity of the profile of the portions 16.

[0034] The embodiments according to the invention previously described enable improvement of the functionality of tanks that are to contain gas at high pressure, at operating pressures higher than 100 bar, on account of the possibility of placing the valve 6 in positions that have a positive impact both on the safety - in so far as the valve is more protected in the case of impact - and on the capacity for storage of fuel in the presence of an increase in exploitable volume for housing the tank body.

[0035] The aforesaid advantages are rendered evident from the representation provided by way of example in Figures 13A and 13B, where the reference number 9 designates an end surface of a boot of a generic motor vehicle of small dimensions. Figures 13A and 13B illustrate, respectively, the case of housing in said boot of a tank 11 according to the embodiment of Figure 2, and of a tank 1 according to the known art appearing in Figure 1.

[0036] In said figure, L designates the maximum axial or longitudinal dimensions of the two tanks.

[0037] As may be noted immediately, given the same dimensions of the boot (and of cross section of the tank), the longitudinal encumbrance of the tank 11 appearing in Figure 13A may be greater than that of the tank 1 appearing in Figure 13B thanks to the different position of the valve 6.

[0038] The larger longitudinal extension of the body 12, and hence the increased storage capacity, is the direct consequence of the fact that, according to the invention, the valve 6 can be positioned in areas of the bodies that are in any case safe.

[0039] From a comparison between Figures 13A and 13B it may be noted how, in the case of the tank 11, the distance between the projecting portion of the valve 6 and the wall 9 of the boot can in any case be greater than the minimum one imposed by the standards (case of Figure 13B), and in any case distant from the surface of the boot facing it, with evident advantages in terms of safety. Said projecting portion of the valve is in any case comprised within the dimension of maximum encumbrance of the body 12.

[0040] It should be noted that the particular positioning of the valve 6 envisaged according to the invention is strictly linked to the conformation of the body 12 and in particular to the presence of the thickened portions 16. In fact, the portions 16 lead to a strengthening of the side area of the head terminal region 15 so as to enable formation of the hole 17 for fixing the valve 6.

[0041] The present invention also envisages the possible presence of more than two portions with thickened walls 16, with the condition that they are arranged with central symmetry with respect to the axis X of the body 12 so as to distribute the circumferential stresses evenly over the cross sections of the body 12. In this connection, there may then also be provided a band with thickened wall that extends circumferentially throughout a cross section of the head terminal region 15.

[0042] In the embodiment previously described, the body 12 of the tank 11 is obtained starting from a single piece, in this case a billet of high-alloy steel.

[0043] With reference to Figures 7 to 12, represented schematically are steps of the method for making the tank according to the invention.

[0044] Figure 7 illustrates a step of pre-forming in which the billet, designated by 20, is compressed under a press 21 for the purpose of obtaining a pre-form.

[0045] Next, a first step of forging is carried out, illustrated in Figure 8, in which the pre-form is inserted in a die 22 and pressed by a counter-die 23 to obtain a form 20b having a longitudinal cross section with a substantially cup-shaped profile, the bottom end of which will define the head terminal region 15 of the body 12.

[0046] Then, a second forging step is carried out that envisages the use of a second counter-die 23', visible in Figure 9. The counter-die 23' has two surface cavities 23b' diametrally opposite with respect to a central axis of the die and counter-die, and defining the matrix of the thickened portions 16. In particular, in the case of the body 12 of the embodiment described above, the cavities 23b have a first area, a second area, and a third area, corresponding, respectively, to the first, second and third areas of the thickened portions 16. The aforesaid areas of the counter-die are characterized by dimensions corresponding to those defined for the portions 16, which, in the case of the embodiment described above, are linked to one another according to the relations given previously. With the second forging step a form 20c is obtained, which defines, at the bottom (as viewed in Figure 10), the head terminal region 15 provided laterally with the thickened portions 16.

[0047] Following upon the second forging step, the form 20c is drawn and coined so as to make a form 20d provided also with the hollow intermediate region 14. In the process of drawing, represented schematically in Figure 10, the part of the form 20c that extends, at the top, to the thickened portions 16 is plastically deformed under the action of forces impressed by rollers 24 that stretch the aforesaid part. The form 20c is thus lengthened until a volume substantially equal to that of the body 12 of the tank 11 is obtained.

[0048] At this point, as illustrated schematically in Figure 11, the form 20d obtained by drawing undergoes a process of sand-blasting, which consists in smoothing the walls with a jet of sand and water under pressure. After sand-blasting, the drawn product, represented by the form 20d, is checked dimensionally and via visual inspection to detect the presence of possible irregularities of the structure that might be capable of impairing the mechanical properties of the finished tank.

[0049] Finally, via a step of fluoforming, represented in Figure 12, the form 20d is closed via the formation of the bottom region 13 according to modalities in themselves known. Specifically, said step envisages setting in rotation the form 20d, which is heated in a position corresponding to its open end and on which a roller 25 acts in such a way as to curve the wall 20d' defining said end in order to form the hemispherical cap that distinguishes the bottom terminal region 13.

[0050] Once the body 12 is made, one of the portions 16 is perforated and, the hole 17 made is threaded internally for the purpose of receiving the threaded stem of the valve 6.

[0051] The invention, as emerges from the embodiments appearing in Figures 2-6, enables, in the case of need, provision also of two distinct valves for one and the same cylinder, for example the one for charging the fluid and the other for drawing it off. Each of said valves would be located in a position corresponding to a respective portion 16 provided with a threaded hole 17, as previously described, the two valves projecting, then, from the two opposite sides of one and the same head terminal region 15.

[0052] The invention has been described with particular reference to the construction of tanks or cylinders for application in the automobile sector, but it is clear that it may also be used in any other field that presents the same specific problems, in particular ones due to the need to guarantee an adequate mechanical sturdiness at operating pressures higher than 100 bar. Likewise, even though the use of the tanks outlined previously has been described with reference to the storage of methane gas, it is clear that they are to be understood as being suitable for storing any other fluid at operating pressures higher than 100 bar, and in particular substantially comprised between 200 and 300 bar.

[0053] Of course, without prejudice to the principle of the invention, the details of construction and the embodiments may vary with respect to what is described and illustrated herein purely by way of example.

Claims

1. A tank for storing a fluid for fuelling a motor-vehicle engine at operating pressures higher than 100 bar, particularly between approximately 200 bar and 300 bar, comprising:

- a body for containing the fluid (12), formed starting from a single piece, the body comprising a head terminal region (15) defining a head end, a bottom terminal region (13) defining a bottom end, and an intermediate region (14) between the head terminal region (15) and the bottom terminal region (13), said bottom end and said head end delimiting an axial dimension (L) of encumbrance of said body (12);
- a valve device (6), for charging the body (12) with the fluid and/or for drawing-off the fluid from the body (12), the device (6) having a fixing portion, operatively inserted and blocked in a through opening (17) defined in a wall of the body (12), and a connection portion, projecting from said wall on the outside of the body (12),

said tank being **characterized in that** said body (12) has, at said head terminal region (15), portions with thickened walls (16) arranged with central symmetry with respect to an axis (X) of the body (12), said through opening (17) being made in at least one of said thickened wall portions (16).

2. The tank according to Claim 1, **characterized in that** said portions with thickened walls are formed by two portions (16) that face laterally the body (12) and are arranged diametrally opposite with respect to the central axis (X).

3. The tank according to Claim 1, **characterized in that** said single piece is made of steel selected in the group consisting of hardened and tempered steels with high equivalent carbon content with ultimate strengths comprised between 800 and 1200 MPa.

4. The tank according to any one of the preceding claims, **characterized in that** said head terminal region (15) and said bottom terminal region (13) have a substantially cup shape, generally flattened for the head terminal region (15), substantially hemispherical for the bottom terminal region (13), and in which said intermediate region (14) has a substantially cylindrical shape.

5. The tank according to Claim 1, **characterized in that** said portions (16) comprise:

- a first area (16a) defining a substantially plane seat and having maximum thickness, at which said through opening (17) is formed;
- a second area (16b) that defines a first area of radiusing and surrounds said first area (16a); and
- a third area (16c), which defines a second area of radiusing and surrounds said first and second areas (16a, 16b).

6. The tank according to Claim 5, **characterized in that** said second and third areas of radiusing (16b, 16c) have curvatures of opposite sign.

7. The tank according to Claim 6, **characterized in that**:

- said thickened portions (16) possess a first and a second characteristic dimension (A, B), defining respectively the width and the height of a front projection of said thickened portions (16);
- said second area (16b) has a third characteristic dimension (R1) defining a first radius of radiusing;
- said third area (16c) has a fourth characteristic dimension (R2) defining a second radius of radiusing;

said characteristic dimensions (A, B, R1 and R2) being correlated with one another according to the relations given below, D being the diameter of the tank:

- said first dimension (A) has a value comprised between 0.45 and 0.51 of D, preferably approximately 0.48 of D;
- said second dimension (B) has a value com-

prised between 0.4 and 0.5 of D, preferably from approximately 0.45 to approximately 0.48 of D;
- said third dimension (R1) has a value comprised between 0.1 and 0.2 of D, preferably approximately 0.13 of D; and
- said fourth dimension (R2) is greater than or equal to 10 mm, preferably greater than or equal to approximately 15 mm.

8. The tank according to Claim 1, **characterized in that** said body (12) is formed in a single piece starting from a steel billet.

9. The tank according to Claim 2, **characterized in that** the connection portion (6B) of the device (6) projects laterally from the body (12), with reference to the longitudinal development of the latter.

10. The tank according to Claim 5, **characterized in that** the body (12) has on an external side, in a position corresponding to said first area (16a), a corresponding (16a') plane external region.

11. A method for the fabrication of a tank for storing a fluid for operating at pressures higher than 100 bar, in particular a gas tank for fuelling a motor-vehicle engine, the method comprising the steps of:

- providing a longitudinally extended hollow body (12) made of steel, having a head terminal region (15) defining a head end, a bottom terminal region (13) defining a bottom end, and an intermediate region (14) between the head terminal region (15) and the bottom terminal region (13);
- providing a valve device (6) with a fixing portion and a connection portion;
- fixing the valve device (6) to the body (12), by inserting and blocking said fixing portion in a through opening (17) made on the body (12), with said connection portion that projects on the outside of the body (12),

where the body (12) is formed starting from a single piece of steel, envisaging the following operations:

a) performing a first forging of the single piece with a first counter-die (23), to obtain a first form (20b) having a longitudinal cross section with a substantially cup-shaped profile, in which said head terminal region (15) is identified;
b) a step of drawing of the single piece, comprising the plastic deformation of an end area of the piece opposite to said head terminal region, said end area being stretched to obtain a further form (20d) that has said intermediate region (14);
c) a step of closing via fluoforming, carried out on said further form (20d), said step comprising a local heating of the single piece and its deformation in order to obtain said bottom terminal region (13),

the method being **characterized in that**:

- prior to the operation b), a second operation is carried out of forging of the single piece, using a second counter-die (23'), for the purpose of obtaining a second form (20c) that has portions with thickened walls (16) in said head terminal region (15), said second counter-die (23') comprising cavities or surface impressions (23b') defining the matrix of said thickened portions (16), said portions with thickened walls being arranged with central symmetry with respect to an axis (X) of the second form (20c),
- said through opening (17) is formed in a position corresponding to one of said portions with thickened walls (16) in order to fix therein said valve device (6).

12. The method according to Claim 11, **characterized in that** it moreover comprises, prior to the operation c), a step of sand-blasting in which said further form (20d) is subjected to a jet of sand and water under pressure for the purpose of smoothing its walls.

13. The method according to Claim 11, **characterized in that** the operation c) comprises;

- setting said further form (20d) in rotation;
- using rollers (25) for deformation of the single body.

14. The method according to Claim 11, **characterized in that** the steel is selected in the group consisting of hardened and tempered steels with high equivalent carbon content and high-strength steels.

15. The tank for storing a fluid at high pressure, in particular a gas for fuelling a motor-vehicle engine, comprising a body (12) made of hardened and tempered steels with high equivalent carbon content or high-strength steel, formed by the method according to one or more of Claims 11 to 13.

FIG. 1

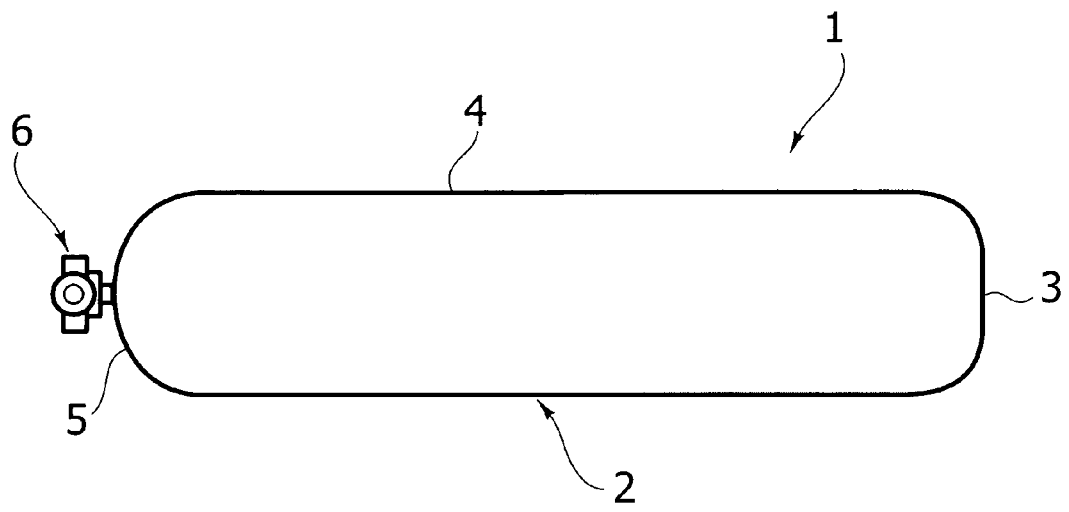


FIG. 2

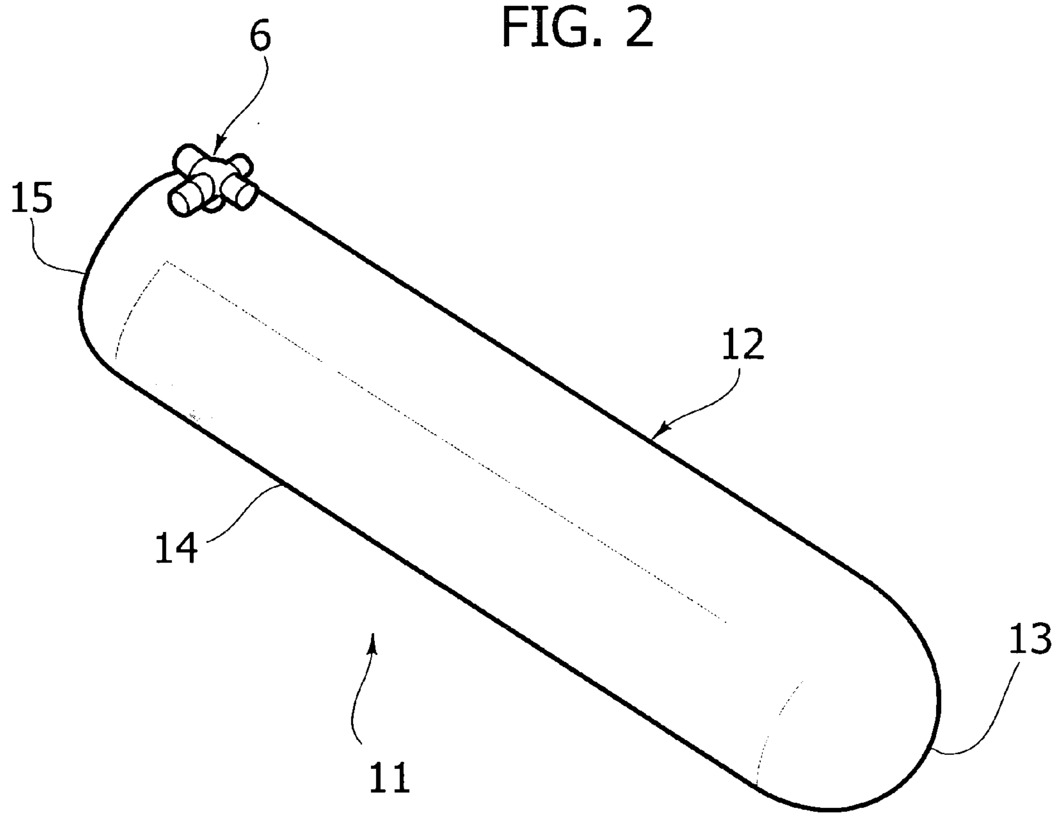


FIG. 3

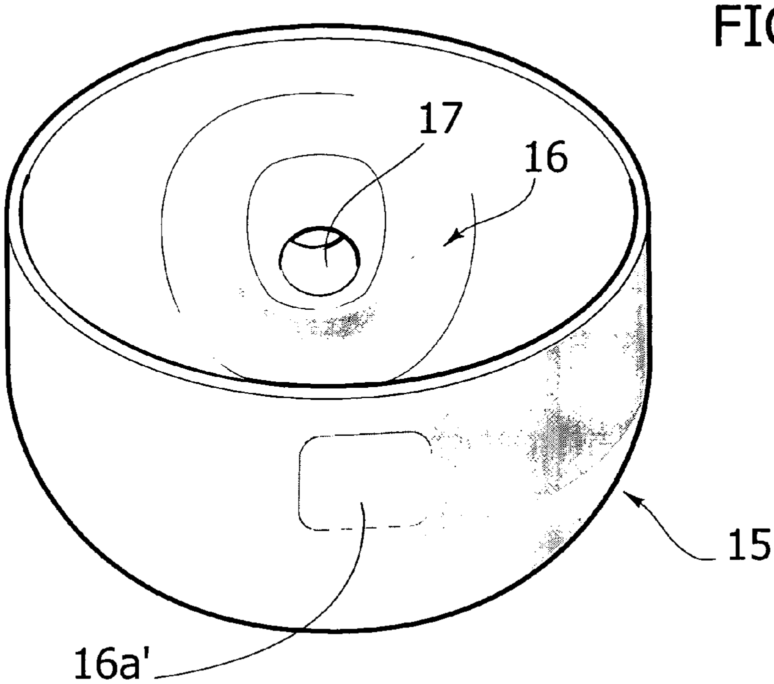


FIG. 4

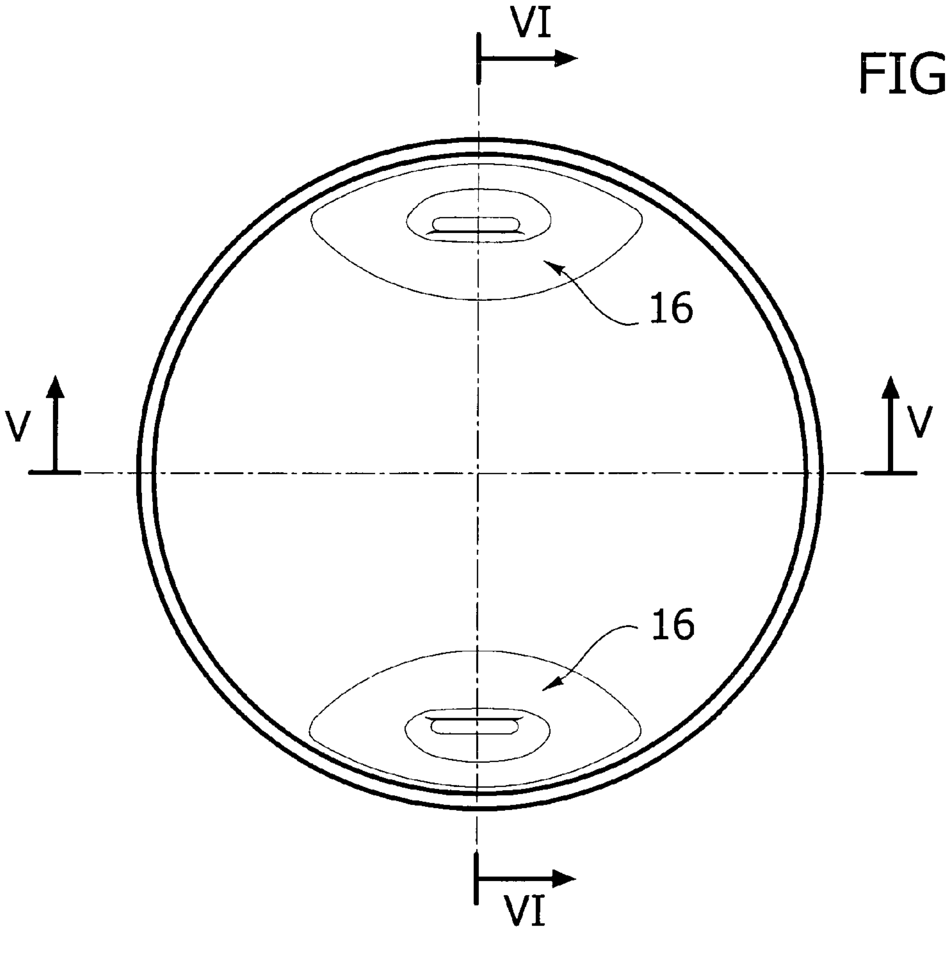


FIG. 5

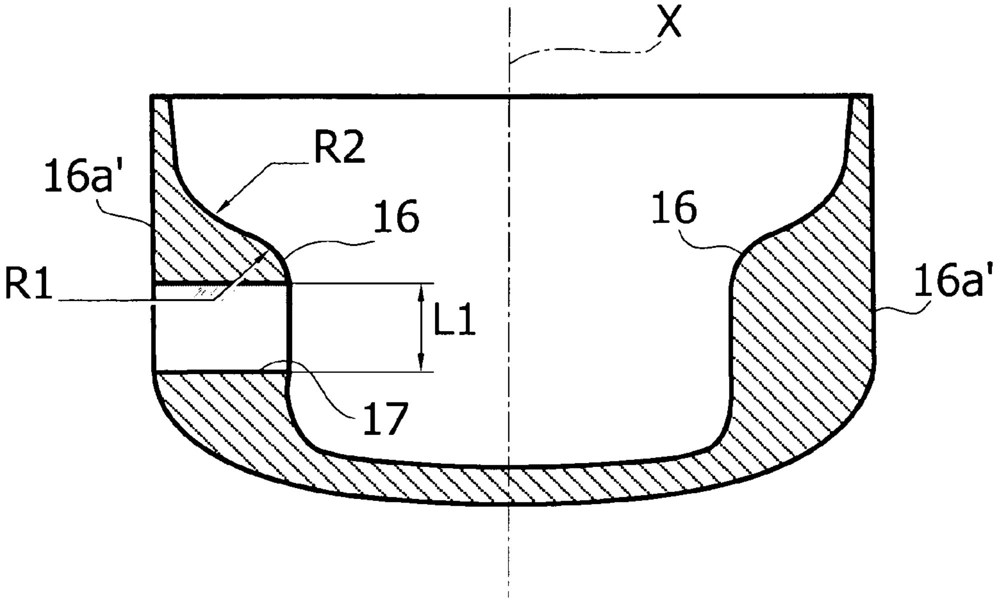


FIG. 6

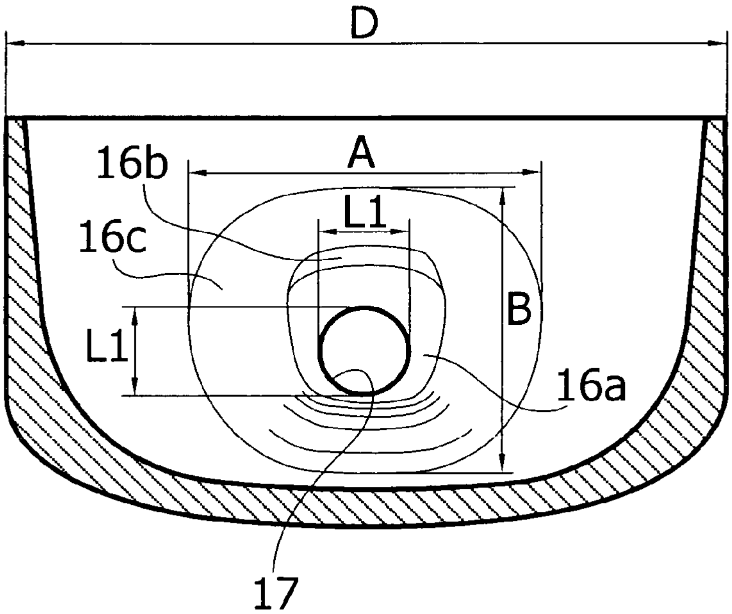


FIG. 7

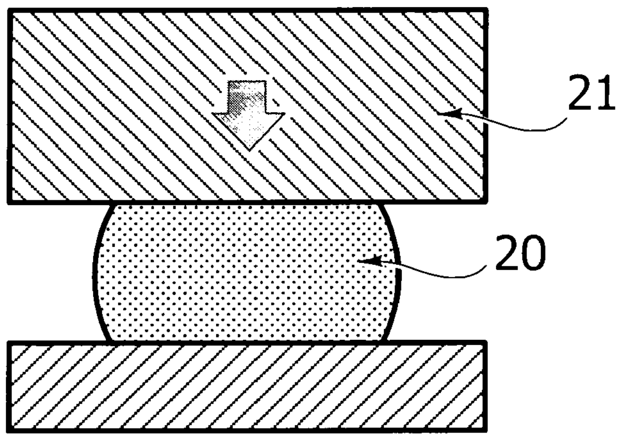


FIG. 8

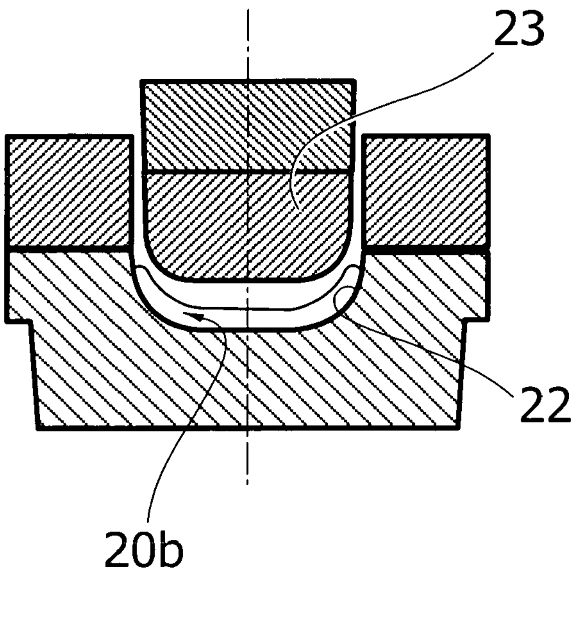


FIG. 9

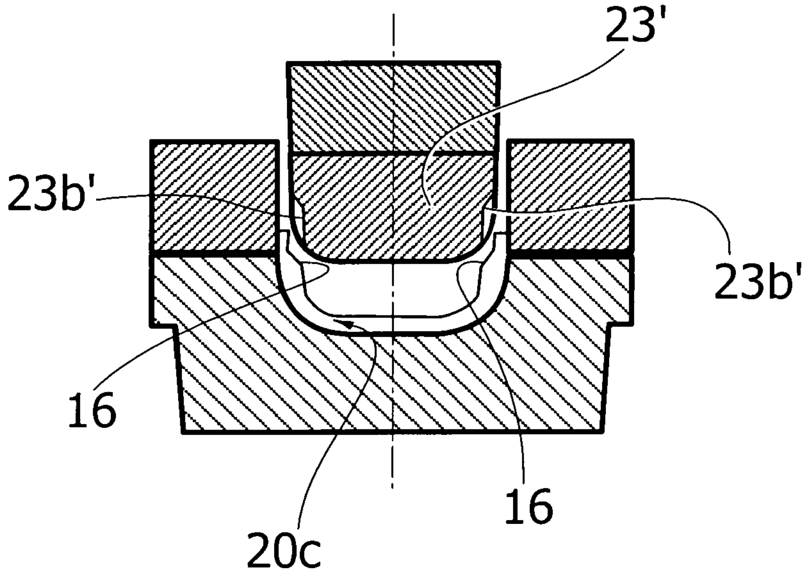


FIG. 10

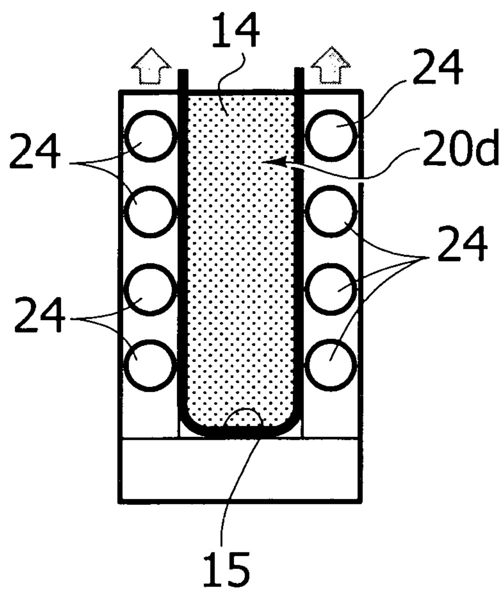


FIG. 11

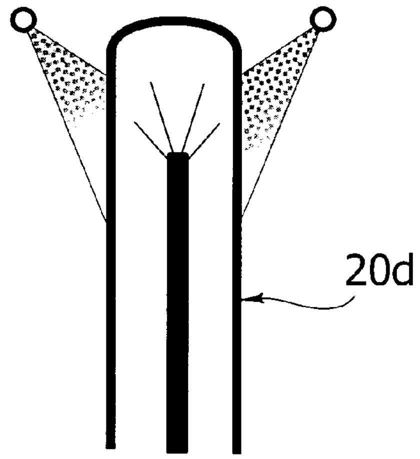


FIG. 12

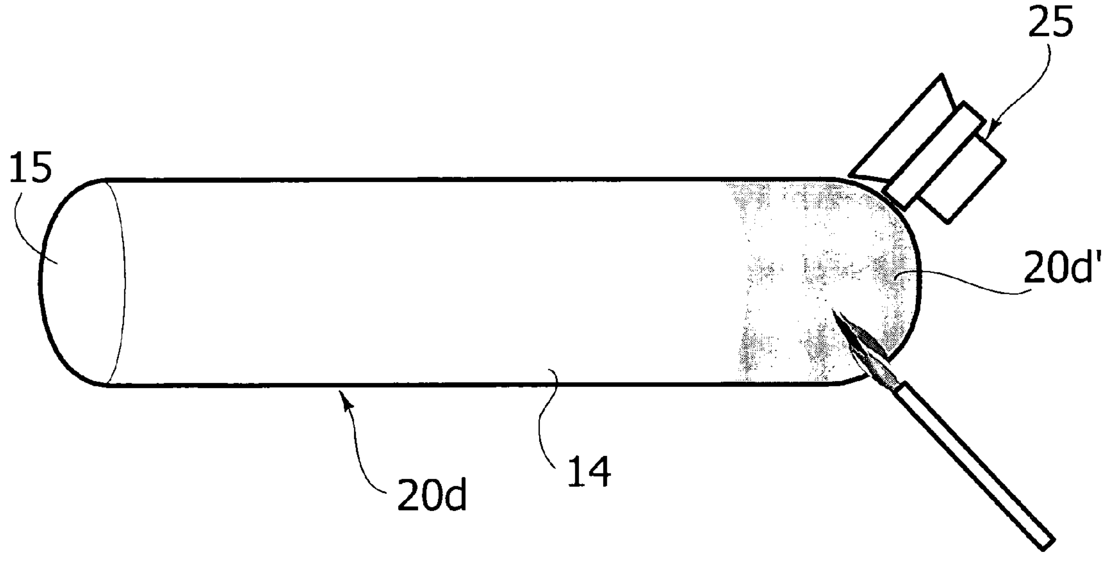


FIG. 13A

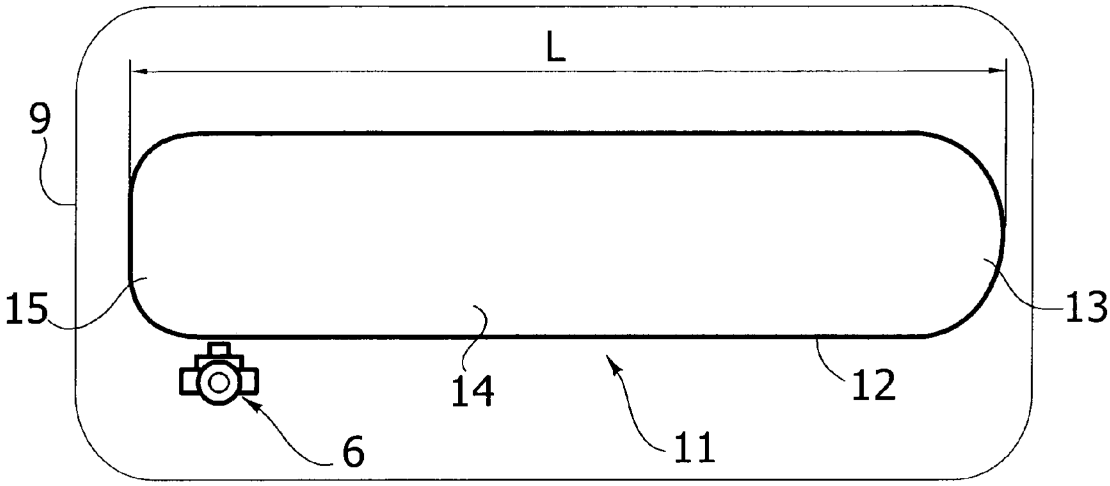
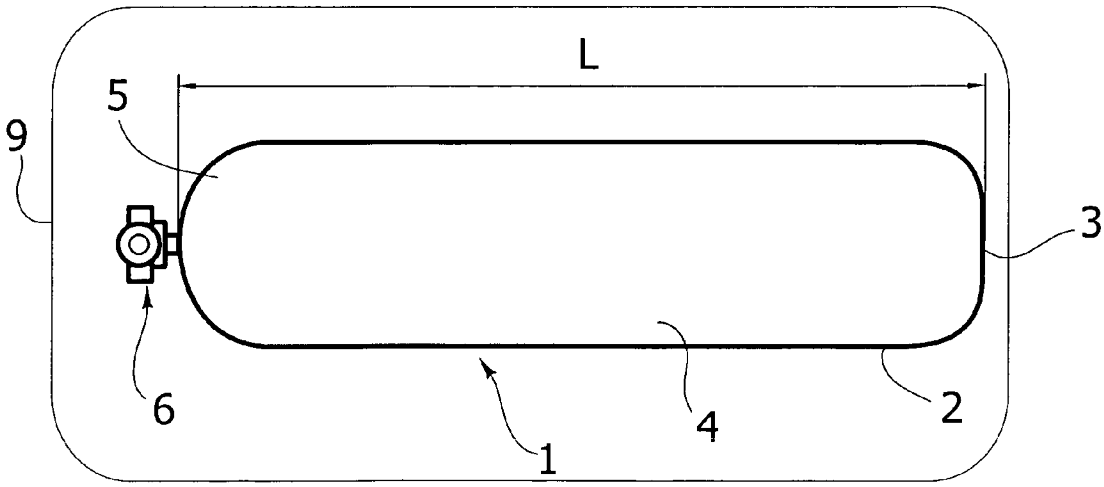


FIG. 13B



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EUROPEAN SEARCH REPORT

Application Number
EP 06 42 5803

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 99/47850 A (MANNESMANN AG [DE]; OSTHOLT RUEDIGER [DE]) 23 September 1999 (1999-09-23) * page 8, line 24 - page 10, line 22 *	1-15	INV. F17C13/08
A	US 2003/006349 A1 (SADOWSKI MARK M M [CA] ET AL) 9 January 2003 (2003-01-09) * paragraph [0041]; figure 2a *	1-15	
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A	GB 482 142 A (HAROLD DICKINSON BRUNTON) 24 March 1938 (1938-03-24) * figure 1 *	1-15	
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			F17C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	9 May 2007	Stängl, Gerhard

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