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(54) A corrosion resistant expansion tank

(57) A first aspect of the invention is directed to a corrosion resistant expansion tank (100) that is divided into two sections (103,106): one that may be pre-charged with a fluid under pressure (for example, a gas) from a first fluid source; and the other being connected to a second fluid source, for example, the hot water source in a hot water heating system. According to this first aspect of the invention, the tank comprises a pair of molded plastic tank sections (101,104) that each integrally include the connection to one of the aforementioned fluid sources; and further include means (107) for separating the interior of the tank into the two sections referred to hereinabove. Examples of such means for separating include application specific membranes (such as diaphragms and bladders of varying types) that are impermeable to the fluids stored in the separate tank sections. Further aspects of the invention relate to apparatus for securing the means for separating within a tank and to processes for cost effectively manufacturing the tanks contemplated by the aforementioned first aspect of the invention.

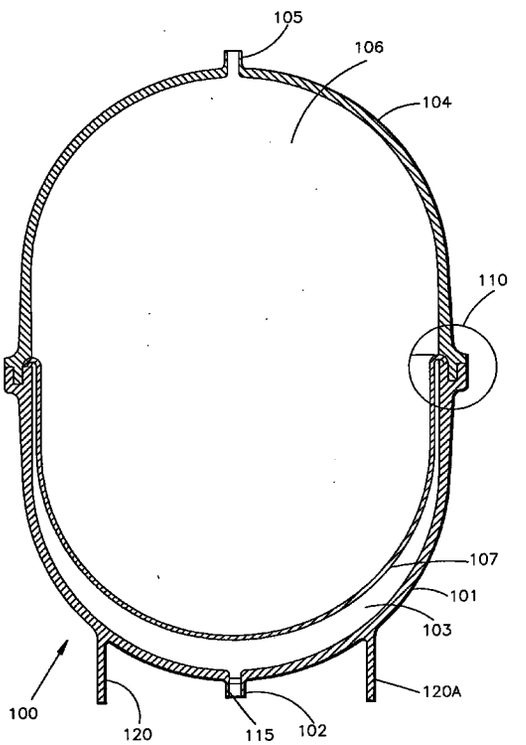

FIG. 1

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Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention generally relates to expansion and storage tanks (hereinafter collectively referred to as expansion tanks) used, for example, in closed hydronic heating systems, pressurized water systems, closed domestic water systems and to expansion tanks that store water in water treatment systems, etc.

More particularly, a first aspect of the invention is directed to a corrosion resistant expansion tank that is divided into two sections: one that may be precharged with a fluid under pressure (for example, a gas) from a first fluid source; and the other being connected to a second fluid source, for example, the hot water source in a hot water heating system.

Tanks contemplated by this first aspect of the invention are fabricated from a pair of molded plastic tank sections that each integrally include the connection to one of the aforementioned fluid sources; and further include means for separating the interior of the tank into the two sections referred to hereinabove. Examples of such means for separating include application specific membranes (such as diaphragms and bladders of varying types) that are impermeable to the fluids stored in the separate tank sections.

Further aspects of the invention relate to apparatus for securing the means for separating within a tank and to processes for cost effectively manufacturing the tanks contemplated by the first aspect of the invention referred to hereinabove.

2. Description of the Related Art

Water contains air in the absorbed state in nearly inverse proportion to its temperature. This air is liberated into the system when the water is heated and accumulates in the compression tank and other portions of the heating system.

A reduction in heating efficiency results, making continuous venting of radiators or convectors necessary. The water as it is heated expands and moves into the compression tank which is connected to the piping through which the water is circulated. When the temperature of the boiler water reaches the desired degree, the firing of the boiler ceases. The water begins to cool and contract. As it cools, that part of the boiler water in direct contact with air in the compression tank absorbs some of the air in the tank.

Through thermal circulation this air charged water in the compression tank is changed continually so that in the next heating cycle this re-absorbed air is liberated into the system. This reversible process is repeated as often as the firing cycle is repeated and the boiler water is heated and cooled. As a result of this process the pressure in the system varies considerably and eventually the system may cease to function.

Expansion tanks in domestic water systems provide an air cushion for the supply water. The air and water in early systems were in direct contact. Air being soluble in water, the water absorbs air. The water in the system might eventually absorb the air cushion in the expansion tanks, leaving a static water system which necessitates the constant operation or rapid cycling of a pressure pump. Subsequently an air surge chamber was provided which was not in direct contact with the water, thereby eliminating the need of the pressure pump operating every time a faucet was turned on.

U.S. Patent No. 3,035,614 discloses expansion tanks which include a pair of hollow body members, each of which have an end and a tubular skirt portion. The skirt portions are united in end-to-end relation to form a tank. There is a flexible diaphragm in and spanning the tank and having a peripheral portion in peripheral engagement with the skirt of one of the body members. A continuous retaining ring engages the peripheral portion and retains it in engagement with the skirt of the body member. There is a groove in the exterior of the ring and a substantially complemental corrugation in the skirt of the body member compressing the peripheral portion into the groove to secure the diaphragm against movement endwise of the tank and seal the diaphragm to the skirt. See also U.S. Patent No. 2,695,753.

U.S. Patent No. 3,524,475, discloses an expansion tank which includes a hollow body having a side wall and end walls and a liquid-impervious liner having an end wall and a side wall covering the corresponding end wall and a portion of the side wall of the body in adjacent non-adhering relation thereto. The liner has a peripheral edge portion contacting the side wall. There is a flexible diaphragm dividing the interior of the body into two sections. One of the sections is adapted to receive a liquid. The diaphragm has a peripheral portion disposed in overlying relation to the peripheral edge portion of the liner. There is also means retaining the peripheral portions of the diaphragm and the liner against the side portions of the diaphragm and the liner. The retaining means includes a continuous ring engaging and receiving the peripheral portion of the diaphragm. The side wall engages the peripheral edge portion of the liner. The ring and wall have a complemental rib and groove securing the diaphragm to the side wall. The diaphragm is formed with a bead on its peripheral portion, with the bead being received between the rib and the groove.

U.S. Patent No. 5,386,925 (assigned to the same assignee as the instant invention; is an improvement over the expansion tank disclosed in U.S. Patent No.3,524,475. The retaining ring that continuously engages the diaphragm and liner to perform a secure seal was modified in the incorporated 5,386,925 patent.

The tanks described in both of the incorporated patents use of a deformable diaphragm to divide a tank into two sections. One section is precharged with gas under

pressure so that the diaphragm is displaced to increase or decrease the volume of this section according to the variations of the volume of water in the other section.

As indicated hereinbefore, when the expansion tank is incorporated in a hot water heating system, the variation in volume is caused when the boiler water is heated and cooled in the normal cyclic operation of the heating system. If the expansion tank is a part of a water system, the variation in volume occurs as tap water is drawn and when the pump operates to replace the water drawn from the tank. The diaphragm separates the gas in the one section of the tank from the water in the system.

In designing metallic expansion tanks, like those described in the above patents, it is important to address corrosion problems which can have a significant adverse effect on the useful life of such tanks. Tank corrosion could become a serious problem it there was direct contact of water (or water vapor) with substantially the entire inner metallic surface of the water receiving section of expansion tanks like those described in the referenced patents. Corrosion is active in hot water system expansion tanks because of the elevated temperature of the water. With water system expansion tanks, the corrosion varies in accordance with the mineral and oxygen content of the water in a given locality. To solve these problems metal tanks, like those described in the incorporated patents, use additional components (like the aforementioned liquid-impervious liner, means for securing a liner within the tank, etc.), to protect the inner surface of the tank section that holds water. Other techniques used to solve the aforementioned problems include coatings and/or surface treatments applied to the inside of a tank.

For the sake of illustration only, reference will be made particularly to U.S. 5,386,925 to point out several of the more significant problems inherent in present day corrosion resistant metallic tanks themselves and the known processes used to manufacture such tanks.

In order to manufacture a steel expansion tank in accordance with the teachings of U.S. 5,386,925 patent, both the liner and diaphragm must be sealed in a metal tank halt (referred to as the "water dome" in U.S. 5,386,925 patent). A retaining ring (yet another internal tank component) is used as an inside support of a cold formed tank seal.

The "air dome" described in U.S. 5,386,925 patent is then welded to the water dome; with care needing to be exercised in the tank design to insure that the weld area is sufficiently spaced from the diaphragm and liner so that these components are not damaged during the welding process (due to the great variance in the melting temperatures of the materials used, such as metal and rubber).

As those skilled in the art will readily appreciate, criteria such as the choice of weld area, amount of weld material used and type of joint being formed, all affect joint strength and tank integrity. Once again, the concern about heat transfer, overheating and melting components installed in the tank, etc., affect the weld and joint type options available to the tank manufacturer.

Additionally, in accordance with the teachings of U.S. 5,386,925 patent, the liner must be sealed to the tank's water connection; and the water connection itself needs to be formed in a separate set of detailed process steps, including brazing or welding the water connection to the water dome tank half.

In summary, U.S. 5,386,925 exemplifies several problems inherent in the structure and manufacturing processes associated with prior art metallic expansion tanks. Tank insert components, such as liners, are required in order to provide corrosion protection; separate tank insert sealing mechanisms, such as retaining rings, are required to seal the liners and diaphragms within the tanks; the liners need to be further sealed at the tank's water connection; the water connection (and the gas connection in many prior art devices) needs to be formed in a set of separate process steps; care must be taken in performing various manufacturing steps that call for the application of heat to avoid damaging the liners and diaphragms being installed during the manufacturing process; and the type and strength of joints formed during tank construction are to a degree affected by the proximity of the internal tank components that can he affected by whatever joint forming process is used.

All of the problems referred to hereinabove add complexity to the tank manufacturing process in terms of number of components and process steps required for tank fabrication; and the care that needs to be exercised throughout the tank fabrication process to assemble the various components, apply heat, etc. These problems and the known solutions to these problems all have an impact on tank reliability, tank life and tank manufacturing costs.

Those skilled in the art will also recognize that corrosion resistant non-metallic (usually plastic) tanks exist. Such tanks obviate the need for a liner to protect the tank from corrosion; however, many of the same problems referred to hereinbefore still affect known plastic tank design and manufacturing processes.

For example, Flomatic produces a plastic tank that is fabricated without the use of a liner. However, a diaphragm (inserted into a tank half) needs to he secured by a hoop pressed into the tank half; and then the two domes (air and gas) are friction-welded together. Additionally, both air and water fittings need to be fastened to the tank. Thus, although the need for a liner is eliminated, the Flomatic tank still requires the use of an internal tank component (the hoop) to secure the diaphragm and still requires the addition of separate air and gas tank connections since these connections are not molded into the tank halves (the domes).

The friction weld step in the process used to fabricate the Flomatic tank is also a potential problem source. Those skilled in the art will readily appreciate such a weld (a friction weld) has a low joint efficiency. In applications where joint efficiency needs to be high

(high pressure containment situations, etc.), to get an improved joint using friction welding the weld surface area needs to be increased. Although not desirable, this additional surface area could be provided, for example, by the use of wider tank components having a greater weld surface area.

Another known plastic tank, the "ROmate" pure water storage vessel manufactured by Structural Fibers (an ESSEF Company) of Chardon, Ohio, takes the form of a one piece blow molded plastic bottle having a bladder installed therein. The Structural Fibers plastic tank requires its water connection to be sealed against the tank and against the bladder; the fastening or welding on of an air connection; and has the potential for losing air charge in field use because inherent weak points at the air stem to bottle interface and at the various other seals (water connection/bladder and tank seals) incorporated into the ROmate design.

Other examples of tanks that illustrate the present state of the art include tanks by Hydrotech (plastic molded and then crimped on the outside to secure a bladder); metallic tanks by Wessels Company of Detroit Michigan fabricated via a process involving the welding of two steel domes and installing a bladder (the resultant tanks having all the problems of steel tanks in general with regard to maintenance, corrosion and the potential for contaminating the stored water, the potential for field failures due to bladder seal failure, etc.); metallic tanks by Well-Rite (fabricated by, for example, clinching two diaphragms inside a welded steel tank or alternatively clinching a single diaphragm between one stainless and one steel dome); and still other tanks which utilize fasteners to literally screw tank parts together.

None of the known tank devices, fabricated in metal, plastic or of any other material, integrate both the air and water connection into parts that are used to fabricate the outer shell of the tank; nor do any of the known tank devices combine the desirable attributes of providing a low maintenance, corrosion resistant tank that can be fabricated using a very small component set (three components according to a preferred embodiment of the present invention); and very simple process steps to assemble to aforementioned component set.

Accordingly, in view of the present state of the art, illustrated by the exemplary tanks taught in the aforementioned patents and further illustrated by the commercially available tanks described hereinabove, it would be desirable to provide a corrosion resistant expansion tank design that (a) inherently resists corrosion and eliminates the need for a liner to be installed in order to provide corrosion protection; (b) does not require the use of separate tank insert sealing mechanisms, such as retaining rings or hoops, to seal a diaphragm, bladder, etc., within the tank; (c) integrates tank connections (both gas and water connections) into parts that are used to fabricate the outer shell of the tank, to thereby eliminate having to form such connections and associated seals in a set of separate process steps; and (d) includes apparatus (means) for securing, within an expansion tank, the means used for separating the interior of the tank into two separate portions and at the same time provide for the joining and sealing together of tank sections used to form the expansion tank fluid containment vessel itself.

Furthermore, it would be desirable to be able to provide a corrosion resistant expansion tank design (and related tank manufacturing process) in which (a) joint efficiency can be increased without having to resort to wider tank components to obtain a greater weld surface area; (b) the aforementioned means for securing is designed to hold the means for separating (e.g., a diaphragm) in place during tank assembly and during tank operation; (c) the aforementioned means for securing is further designed to provide a vehicle for forming a strong interior lap joint to replace, for example, weaker prior art friction welds, etc.; (d) the number of manufacturing steps that call for the application of heat during the manufacturing process and the number of internal tank components that can be affected by whatever joint forming process is used, are minimized; and (e) the overall complexity of the tank manufacturing process is reduced in terms of number of components and process steps required for tank fabrication to thereby improve reliability, tank life and lower tank manufacturing costs.

SUMMARY OF THE INVENTION

Accordingly, preferred embodiments of the invention provide improved expansion tanks for use in hot water heating systems, pressurized water systems, and the like.

Preferred embodiments of the invention provide improved expansion tanks, for use as indicated hereinabove, which are corrosion resistant.

Furthermore, preferred embodiments of the invention provide a corrosion resistant expansion tank that may be divided into two sections: one that may be precharged with a fluid under pressure (for example, a gas) from a first fluid source; and the other being connected to a second fluid source, for example, the hot water source in a hot water heating system.

A preferred embodiment of the invention provides a corrosion resistant expansion tank that can be fabricated from a pair of tank sections (preferably molded plastic tank sections) that each integrally include the connection to one of the aforementioned fluid sources; and further include means for separating the interior of the tank into the two sections referred to hereinabove.

A preferred embodiment of the invention is to provides a corrosion resistant expansion tank design that (a) inherently resists corrosion and eliminates the need for a liner to be installed in order to provide corrosion protection; (b) does not require the use of separate tank insert sealing mechanisms, such as retaining rings or hoops, to seal a diaphragm, bladder, etc., within the tank; (c) integrates tank connections (both gas and water connections) into parts that are used to fabricate

the outer shell of the tank, to thereby eliminate having to form such connections and associated seals in a set of separate process steps; and (d) includes apparatus for securing, within an expansion tank, the means used for separating the interior of the tank into two separate portions and at the same time provide for the joining and sealing together of tank sections used to form the expansion tank fluid containment vessel itself.

Furthermore, a preferred embodiment of the invention to provides a corrosion resistant expansion tank design (and related tank manufacturing process) in which (a) joint efficiency can be increased without having to resort to wider tank components to obtain a greater weld surface area; (b) the aforementioned means for securing is designed to hold the means for separating (e.g., a diaphragm) in place during tank assembly and during tank operation; (c) the aforementioned means for securing is further designed to provide a vehicle for forming a strong interior lap joint to replace, for example, weaker prior art friction welds, etc.; (d) the number of manufacturing steps that call for the application of heat during the manufacturing process and the number of internal tank components that can be affected by whatever joint forming process is used, are minimized; and (e) the overall complexity of the tank manufacturing process is reduced in terms of number of components and process steps required for tank fabrication to thereby improve reliability, tank life and lower tank manufacturing costs.

The aforementioned embodiments of the invention are achieved in part by providing a pair of tank sections that integrally include first and second fluid connection means (for example, water and gas connection means) which when joined together (the tank sections), with a diaphragm, bladder or other means for separating secured therebetween, form the expansion tank fluid containment vessel.

More particularly, a first embodiment is directed to a corrosion resistant expansion tank that is divided into two sections, one of which may (although not necessarily) be precharged with a fluid under pressure (for example, a gas) from a first fluid source; while the other section is connected to a second fluid source, for example, the hot water source in a hot water heating system.

According to a preferred embodiment of the invention, the tank comprises a pair of molded plastic tank sections. Each of the molded plastic tank sections is designed to integrally include the connection to one of the aforementioned fluid sources. The tanks are further designed to include the means for separating the tank interior into the two sections referred to hereinabove.

Further preferred embodiments of the invention relate to apparatus (means) for securing the means for separating within a tank; and to processes for cost effectively manufacturing the tanks contemplated by the aforementioned first aspect of the invention.

According to a specific first embodiment of the invention, a corrosion resistant expansion tank, comprises: (a) a first molded plastic tank section integrally including first connection means for enabling fluid from a first fluid source to be placed in fluid communication with a first interior portion of the expansion tank; and (b) a second molded plastic tank section, which when joined together with the first molded plastic tank section forms the expansion tank fluid containment vessel, integrally including second connection means for enabling fluid from a second fluid source to be placed in fluid communication with a second separate interior portion of the expansion tank.

The aforementioned first and second connection means provide passageways through which fluid from the first and second fluid sources respectively, may be introduced into and may be withdrawn from the expansion tank.

Furthermore, according to the aforementioned specific first embodiment of the invention, the tank comprises means for separating the tank into the aforementioned first and second interior portions, where the means for separating spans the interior of the tank and is made of a flexible material that is impermeable to a predetermined set of fluids, including those fluids provided by the aforementioned first and second fluid sources. In practice, the means for separating can be realized by, for example, a flexible diaphragm or bladder.

Still further, according to the aforementioned specific first embodiment of the invention, the tank includes a means for securing the means for separating (within the tank) via a joint formed between the first and second molded plastic tank sections.

The means for securing, according to yet another aspect of the invention, preferably comprises: (a) a socket, integrally formed in the first molded plastic tank section, for receiving: (a1) a tang integrally formed on the aforementioned second molded plastic tank section; and (a2) a joint forming material, deposited into the socket during tank assembly, for use in joining aforementioned first molded plastic tank section to the second molded plastic tank section and securing the means for separating therebetween; and (b) a tang, integrally formed in the second molded plastic tank section, designed for insertion into the socket for use in joining the first molded plastic tank section and the second molded plastic tank section together to form the expansion tank fluid containment vessel.

According to a preferred embodiment of the invention the socket and tang further comprise (a) a first socket surface and first tang surface respectively, designed to accommodate the installation and securing of a portion of the means for separating therebetween, with the means for separating being shaped to facilitate the engagement of a portion of the means for separating with at least a portion of the first socket surface during tank assembly; and (b) a second socket surface and second tang surface respectively, which when juxtaposed form a stop. Furthermore, the second socket surface and second tang surface are preferably located in proximity to the exterior wall of the tank (in relation to the combination of the socket, the portion of the means for

separating being secured and the tang itself, the aforementioned combination being located toward the interior wall of said tank).

Furthermore, according to further embodiments the aforementioned joint forming material may be characterized as a material that includes a thermoplastic, such as commercially thermoplastic composite materials formed as a mixture of thermoplastic and metal particles; or a welding material which flows upon being heated. One particularly useful welding material contemplated by the invention is a mixture of thermoplastic and metal particles.

Further yet, according to a preferred embodiment of the invention, the aforementioned socket and tang are designed such that welding material deposited in the socket, upon being heated and upon being compressed by the socket and tang being forced together until the aforementioned stop is reached, flows from the point of deposit in the socket away from the stop and toward the combination of the socket, the portion of the means for separating being secured and the tang, to form an interior lap joint.

According to one embodiment of the invention, the interior lap joint forms a weld that joins the tang and socket, together; but does not include the means for separating as part of the joint. For example, a means for separating made of rubber would not be included in welds contemplated by this embodiment of the invention. However, according to another embodiment of the invention, the interior lap joint forms a weld that joins the tang, socket and the aforementioned means for separating, together. Such a weld could be employed where the material used to fabricate the means for separating has a melting temperature that approximates that of the tank sections (the tang and socket portions thereof) and weld material. For example, the means for separating could be fabricated using a flexible thermoplastic material such as a thermoplastic elastomer/thermoset rubber composite.

According to an alternate embodiment of the invention, a corrosion resistant expansion tank contemplated by the teachings herein comprises: (a) a first molded plastic tank section including a first tank connection integrally molded therein; (b) a second molded plastic tank section, which when joined together with the first molded plastic tank section forms the expansion tank fluid containment vessel, including a second tank connection integrally molded therein; (c) means for separating the tank into a first interior portion and a second interior portion, the means for separating being secured between the first molded tank section and the second molded plastic tank section; and (d) means for securing the means for separating in a joint formed between the first molded tank section and the second molded plastic tank section.

According to this alternate embodiment of the invention, the first molded plastic tank section further comprises (a) a gas dome which may be connected to a gas source via the first tank connection integrally molded in the first molded plastic tank section, wherein said gas dome includes a sealing surface; (b) the second molded plastic tank section further comprises a water dome, designed to fit into the gas dome, which may be connected to a water source via the second tank connection integrally molded in the second molded plastic tank section; (c) at least a portion of the means for separating is formed to fit onto (and/or, "into", defined herein to be included in the term "onto") the sealing surface of the gas dome; and (d) the portion of the means for separating is sealed between the gas dome and the water dome by fitting the portion of the means for separating into the sealing surface and then joining the gas dome and said water dome together to form a lap joint by compressing a material that includes a thermoplastic (or some other welding material), until a stop is reached.

As indicated hereinbefore, further aspects of the invention are directed to the apparatus (means) for securing the means for separating within a tank per se (the novel means for securing having been described hereinbefore); and to processes for cost effectively manufacturing the tanks contemplated by the various embodiments of the invention referred to hereinabove.

In particular, an embodiment contemplates a process for manufacturing a corrosion resistant expansion tank, comprising the steps of: (a) fabricating a first plastic tank section that integrally includes first tank connection means; (b) fabricating a second plastic tank section that integrally includes second tank connection means; (c) inserting between the first plastic tank section and the second plastic tank section, means for separating the tank into a first interior portion and a second interior portion; and (d) joining the first plastic tank section and the second plastic tank section, with the means for separating inserted therebetween, to thereby form the expansion tank fluid containment vessel with the means for separating secured therein.

Further exemplary process steps contemplated by this aspect of the invention include the steps of: (a) integrally forming a socket in the first plastic tank section for receiving the deposit of a joint forming material and for receiving a tang formed as part of the second molded plastic tank section; and (b) integrally forming a tang in the second molded plastic tank section that when inserted into the socket and joined therewith form the expansion tank fluid containment vessel.

According to a preferred embodiment of the invention the step of forming a socket further comprises the step of forming a first socket surface and the step of forming a tang further comprises the step of forming a first tang surface, wherein the first socket surface and the first tang surface are designed to accommodate the insertion and securing of a portion of the means for separating therebetween.

Furthermore, according to a preferred embodiment of the invention, the portion of the means for separating to be secured is shaped to facilitate its engagement with at least a portion of the first socket surface during tank

assembly; and at least a portion of the first tang surface is roughened to enhance the ability of the portion of the means for separating to be secured between the first tang surface and the first socket surface.

Still further, the preferred embodiment of the invention contemplates the following manufacturing steps: (a) forming a second socket surface and second tang surface, wherein the second socket surface and the second tang surface when juxtaposed form a stop; (b) forming the second socket surface and second tang surface in proximity to the exterior wall of the tank (in relation to the first socket surface and the first tang surface which are formed in proximity to the interior wall of the tank; and (c) shaping the socket and tang such that welding material deposited in the socket, upon being heated and upon being compressed by the socket and tang being forced together until the stop is reached, flows from the point of deposit in the socket away from the stop (toward the combination of the socket, the portion of the means for separating being secured and tang), to form an interior lap joint.

Further yet, according to a preferred embodiment of the invention, the first plastic tank section and the second plastic tank section are formed via an injection molding process; and the aforementioned manufacturing step of joining further comprises the steps of: (a) depositing a welding material (such as the aforementioned mixture of thermoplastic and metal particles) into the socket; (b) heating the welding material; and (c) compressing the heated welding material between the socket and tang until the stop is reached.

An alternative process for manufacturing an expansion tank, as contemplated by the invention, comprises the steps of: (a) fabricating a one piece molded plastic gas dome including an integrally formed socket, further including a sealing surface, and gas connection; (b) fabricating a one piece molded plastic water dome including an integrally formed tang and water connection; (c) fitting a diaphragm onto the sealing surface of the socket; (d) depositing a welding material into the socket; (e) heating the welding material; and (f) compressing the heated welding material between the socket and tang until a stop formed by the socket and tang is reached.

The embodiments as exemplified by the various aspects thereof described hereinabove, features (when compared with the prior art described hereinbefore): (a) fewer parts; (b) fluid connections molded into the tank sections (domes) that when joined (the tank sections) form the containment vessel itself; (c) the use of plastic materials that do not require liners or seals; (d) a diaphragm (or bladder, etc.) captured between the domes; (e) a simplified set of production processes; (f) a tank that is corrosion resistant inside and out; (g) a tank that does not require outside finishing (e.g., painting) for finish protection; (h) a reliable tank that can safely be utilized for a variety of applications including water storage applications and high pressure environments due to the inherent strength of the lap joint formed using the process described hereinbefore; and (i) a tank that can be taken apart by reheating the aforementioned interior lap joint, for inspection, repair and/or recycling purposes.

These and other objects, embodiments and features of the present invention and the manner of obtaining them will become apparent to those skilled in the art, and the invention itself will be best understood by reference to the following Detailed Description read in conjunction with the accompanying Drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical cross-section view of an expansion tank contemplated by one embodiment of the invention. FIG. 1A is a vertical cross-section view of the tank depicted in FIG. 1 carrying an air charge.

FIG. 2 is an enlarged vertical partial cross sectional view of a portion of the expansion tank depicted in FIG. 1 depicting exemplary means for securing a means for separating (the interior of the tank into two portions) between the tank sections, wherein the depicted means for securing holds the means for separating (e.g., a diaphragm) in place during tank assembly, during tank operation and provides a vehicle for forming a strong interior lap joint to replace, for example, weaker prior art friction welds, etc. More particularly, in FIG. 2 depicts portions of the tank sections and means for separating prior to these components being joined and secured together.

FIG. 3 and FIG. 3A depict the components shown in FIG. 2 joined together and secured in accordance with a first and second embodiment of the invention, respectively.

FIG. 4 is a vertical cross-section view of an alternate embodiment of an expansion tank contemplated by the invention in which one of the fluid connections is shown molded in a different portion of one of the tank sections.

FIG. 5 depicts, in the form of a flow diagram, a set of tank manufacturing process steps contemplated by an illustrative embodiment the invention.

FIG. 6 depicts, in the form of a flow diagram, a different set of tank manufacturing process steps (differing from the set of steps depicted in FIG. 5), as contemplated by an alternate embodiment the invention.

DETAILED DESCRIPTION

An illustrative embodiment of a corrosion resistant tank of the type contemplated by the invention will be set forth hereinafter with reference to FIGS. 1-4.

It is intended that the following description of the tank, means for securing used in the tank (during the tank construction process and during tank operation), etc., all depicted FIGS. 1-4, will teach the principals of the invention. Those skilled in the art will readily appreciate that the teaching is being set forth in the context of an exemplary tank structure only and that such structure may be varied in practice without departing from

the spirit or scope of the invention which is intended to be limited by the claims only.

In particular, those skilled in the art should readily appreciate that in the context of presenting the illustrative embodiment of the invention certain terms will be used for the sake of illustration only. For example, reference will sometimes be made herein to "air", "gas" and/or "water" as the fluids to be contained in the tank; but these particular fluids are meant to be illustrative in nature only since the tanks contemplated by the invention may be used as fluid containment vessels in general (without limitation as to the type of fluids being contained therein). A further example is that specific references are made hereinafter to a "diaphragm" as a means for separating the interior of the illustrative tank into two sections; however, alternate means for performing the desired separation (like a bladder) are contemplated by the invention as well.

Finally, before describing the instant invention and for the sake of completeness, reference should be made to the U.S. 5,386,925 patent, in which shows hot water heating systems and pressurized water systems in general (shown in schematic form in FIG. 3 and FIG. 4 of the reference), in which the tank taught herein may be used.

Reference should now be made to FIG. 1 which, as indicated hereinbefore, is a vertical cross-section view of an expansion tank contemplated by one embodiment of the invention.

According to this illustrative embodiment of the invention (also a preferred embodiment of the invention), a corrosion resistant expansion tank 100 as shown in FIG. 1, includes: (a) a first molded plastic tank section 101, integrally including first connection means 102, for enabling fluid from a first fluid source (not shown) to be placed in fluid communication with a first interior portion 103 of expansion tank 100; and (b) a second molded plastic tank section 104, which when joined together with first molded plastic tank section 101 forms the expansion tank fluid containment vessel 100, integrally including second connection means 105 for enabling fluid from a second fluid source (not shown) to be placed in fluid communication with a second separate interior portion 106 of expansion tank 100.

First connection means 102 and second connection means 105 provide passageways through which fluid from the first and second fluid sources respectively, may be introduced into and may be withdrawn from expansion tank 100. According to one embodiment of the invention, first connection means 102 and second connection means 105 are threaded (as shown for example at 115 in FIG. 1) to permit easy installation of valves (not shown) into the depicted passageways. Exemplary tank 100 shown in FIG. 1 also includes tank stand member 120 (and corresponding portion 120a of that member in the depicted vertical cross-section view), which is preferably integrally formed (although this is not a requirement to practiced the invention) as part of tank section 101 to serve as a base upon which the tank may be rested in an upright position.

Furthermore, according to the aforementioned preferred embodiment of the invention, tank 100 includes means for separating (shown as 107 in FIG. 1) tank 100 into the aforementioned first and second interior portions (103 and 106 respectively, with first interior portion 103 being located between means for separating 107 and the interior wall of tank section 101); where means for separating 107 spans the interior of tank 100 and is made of a flexible material that is impermeable to a predetermined set of fluids, including those fluids provided by the aforementioned first and second fluid sources.

In practice, means for separating 107 can be realized by, for example, a flexible diaphragm, bladder or some other application specific membrane that separates a the expansion tank into two chambers. For many water storage and water heating applications it is desirable that separate water and air chambers be formed using a material that is not permeable to gas and which allows the air chamber to be precharged. A vertical crops-section view of the tank depicted in FIG. 1 carrying an air charge, is illustrated in FIG. 1A where means for separating 107 (in tank 125), is shown deformed by the air charge at 126.

Still further with reference to FIG. 1, according to the aforementioned preferred embodiment of the invention, tank 100 includes means for securing (shown as 110 in FIG. 1) the means for separating 107 (within tank 100) via a joint formed between first molded plastic tank section 101 and second molded plastic tank section 104.

Reference should now be made to FIGS. 2, 3 and 3A, where means for securing 110 from FIG. 1 is shown in greater detail. In particular, means 110 is shown in FIG. 2 to be holding means for separating 107 (e.g., a diaphragm) in place during tank assembly. The same means 110 is designed to hold means for separating 107 in place during tank operation (illustrated by the diagram shown in FIG. 3) and provides a vehicle for forming the aforementioned strong interior lap joint (also shown in FIG. 3, at 150) to replace, for example, the weaker prior art friction welds, etc., discussed hereinbefore.

In FIG. 2, the depicted portions of tank sections 101 and 104; and means for separating 107, are shown prior to these components being joined and secured. In FIG. 3, the components depicted in FIG. 2 are shown joined together and secured in accordance with a preferred embodiment of the invention.

More particularly, as may be seen with reference to FIG. 2 and according to yet another embodiment of the invention, means for securing 110 (a specific illustrative embodiment of the preferred securing mechanism) is shown to include socket 170, integrally formed in first molded plastic tank section 101, for receiving: (a) tang 171, integrally formed on the aforementioned second molded plastic tank section 104; and (b) joint forming material 172, deposited into socket 170 during tank assembly, for use in joining first molded plastic tank sec-

tion 101 to second molded plastic tank section 104 and securing means for separating 107 therebetween. Tang 171 is shown in FIG. 2 to be integrally formed in second molded plastic tank section 104 and is designed for insertion into socket 170 for use in joining first molded plastic tank section 101 and second molded plastic tank section 104 together to form the expansion tank fluid containment vessel.

According to a preferred embodiment of the invention, as may be seen with reference to FIG. 2, socket 170 and tang 171 further include (a) first socket surface 175 and first tang surface 176 respectively, designed to accommodate the installation and securing of a portion of means for separating 107 therebetween, with means for separating 107 being shaped to facilitate the engagement of a portion of the means for separating with at least a portion of first socket surface 175 during tank assembly; and (b) second socket surface 177 and second tang surface 178 respectively, which when juxtaposed form stop 199 as shown in FIG. 3.

Furthermore, second socket surface 177 and second tang surface 178 are preferably located in proximity to the exterior wall of the tank (in relation to the combination of socket 170, the portion of the means for separating 107 being secured and tang 171 itself, the aforementioned combination being located toward the interior wall 190 of tank 100). As will be explained hereinafter, this arrangement helps form an interior lap joint which strengthens the combination of components that form the tank.

Additionally, according to further embodiments invention, the aforementioned joint forming material (172) may be characterized as a material that includes a thermoplastic, such as commercially thermoplastic composite materials formed as a mixture of thermoplastic and metal particles; or a welding material which flows upon being heated. Weld coil 195 is shown in FIG. 2 and FIG. 3 as a well known means for heating joint forming material 172. One particularly useful commercially available welding material contemplated by the invention is a mixture of thermoplastic and metal particles manufactured by Emabond (a registered trademark) Systems, a division of Ashland Chemical Company.

Further yet, according to a preferred embodiment of the invention, the aforementioned socket 170 and tang 171 are designed such that welding material 172 deposited in socket 170, upon being heated and upon being compressed by socket 170 and tang 171 being forced together until the aforementioned stop 199 is reached, flows from the point of deposit in socket 170 away from stop 199 and toward the combination of socket 170, the portion of the means for separating 107 being secured and tang 171, to form the desired interior lap joint 150 depicted in FIG. 3.

An alternate embodiment of the invention is depicted in FIG. 3A where an interior lap joint, 151, is formed that includes means for separating 107 as well as a portion of socket 170 and tang 171 in the weld. As indicated hereinbefore, this embodiment is feasible where the means for separating is made, for example, using a thermoplastic material that has a melting temperature that approximates that of the tank sections (the socket 170 and tang 171 portions thereof) and the weld material.

This arrangement would relax the need for dimensional controls in the socket and tang. Furthermore, this arrangement would eliminate issues involving the compression set of the diaphragm (means for separating) material and the entire tank would be recycleable without having to be taken apart if the means for separating were made using all recycleable material (such as a thermoplastic), assuming any air charge was first removed.

According to an alternate characterization of the invention, a corrosion resistant expansion tank (like tank 100 of FIG. 1) embodying the invention comprises: (a) a first molded plastic tank section (such as tank section 101) including a first tank connection (like connection 102) integrally molded therein; (b) a second molded plastic tank section (such as tank section 104), which when joined together with first molded plastic tank section 101 forms the expansion tank 100 fluid containment vessel, including second tank connection 105 integrally molded therein; (c) means for separating the tank into a first interior portion and a second interior portion (means 107), means for separating 107 being secured between first molded tank section 101 and second molded plastic tank section 104; and (d) means for securing (110) the means for separating (107) in a joint (150) formed between first molded tank section 101 and second molded plastic tank section 104.

According to this alternate embodiment of the invention, first molded plastic tank section 101 may be further characterized as a gas dome which may be connected to a gas source (not shown) via the first tank connection 102 integrally molded in first molded plastic tank section 101, wherein the gas dome includes a sealing surface (shown in part at 176 in FIG. 2); and where second molded plastic tank section 104 may be further characterized as a water dome, designed to fit into the gas dome, which may be connected to a water source via the second tank connection 105 which is integrally molded in second molded plastic tank section 104.

According to this alternate embodiment of the invention, at least a portion of means for separating 107 is formed to fit onto sealing surface 176 of the gas dome; and that portion of means for separating 107 is sealed between the gas dome and the water dome by fitting the aforementioned portion of the means for separating (107) into sealing surface 176 and then joining the gas dome and said water dome together to form lap joint (as shown, for example, at 150 in FIG. 3 or 151 in FIG. 3A) by compressing a material that includes a thermoplastic, such as commercially thermoplastic composite materials formed as a mixture of thermoplastic and metal particles (or some other welding material) until stop 199 (also shown, for example, in FIG. 3 and FIG. 3A) is reached.

An alternate embodiment of the invention is shown in FIG. 4 which, as previously indicated, is a vertical cross-section view of an expansion tank in which one of the fluid connections to the tank is shown molded in a different portion of one of the tank sections. This may be observed with reference to location 189 in FIG. 4. Depending on the application for the expansion tank, it may be desirable to form a given fluid connection at still other locations in a tank section. FIG. 4 is presented for the purpose of illustrating one way in which a fluid connection could be formed in tank section 101, where the formation of the connection differs from the location of connection 102 shown in FIG. 1.

As indicated hereinbefore, other aspects of the invention are directed to processes for cost effectively manufacturing the tanks contemplated by the various embodiments of the invention referred to hereinabove. These will now be described with reference to FIG. 5 and FIG. 6.

As previously indicated FIG. 5 depicts, in the form of a flow diagram, a set of tank manufacturing process steps contemplated by an illustrative embodiment the invention. FIG. 6 depicts, in the form of a flow diagram, a different set of tank manufacturing process steps contemplated by an alternate embodiment the invention.

In particular, with reference to FIG. 5, it may be seen that one embodiment of the invention contemplates a process for manufacturing a corrosion resistant expansion tank, comprising the steps of: (a) fabricating a first plastic tank section that integrally includes first tank connection means (shown as step 201 in FIG. 5); (b) fabricating a second plastic tank section that integrally includes second tank connection means (shown as step 202 in FIG. 5); (c) inserting between the first plastic tank section and the second plastic tank section, means for separating the tank into a first interior portion and a second interior portion (shown as step 203 in FIG. 5); and (d) joining the first plastic tank section and the second plastic tank section, with the means for separating inserted therebetween, to thereby form the expansion tank fluid containment vessel with the means for separating secured therein (shown as step 204 in FIG. 5).

Further exemplary process steps contemplated by this embodiment of the invention include the steps of: (a) integrally forming a socket in the first plastic tank section for receiving the deposit of a joint forming material and for receiving a tang formed as part of the second molded plastic tank section (this is preferably done as part of step 201 but could be performed as part of a separate process step); and (b) integrally forming a tang in the second molded plastic tank section that when inserted into the socket and joined therewith form the expansion tank fluid containment vessel (this is preferably done as part of step 202 but could be performed as part of a separate process step as well).

According to a preferred embodiment of the invention the step of forming a socket further comprises the step of forming a first socket surface and the step of forming a tang further comprises the step of forming a first tang surface, wherein the first socket surface and the first tang surface are designed to accommodate the insertion and securing of a portion of the means for separating therebetween.

Furthermore, according to a preferred embodiment of the invention, the portion of the means for separating to be secured is shaped to facilitate its engagement with at least a portion of the first socket surface during tank assembly; and at least a portion of the first tang surface is roughened to enhance the ability of the portion of the means for separating to be secured between the first tang surface and the first socket surface. These preferred process steps are optional, but recommended. The step of roughening the first tang surface may be performed as part of step 202 or in a separate process step. The step of shaping may be performed as part of step 203 discussed hereinabove (the inserting step), hut also may be performed in a separate process step not shown in FIG. 5 since it is optional.

Still further, the preferred embodiment of the invention contemplates the following manufacturing steps: (a) forming a second socket surface and second tang surface, wherein the second socket surface and the second tang surface when juxtaposed form a stop; (b) forming the second socket surface and second tang surface in proximity to the exterior wall of the tank (in relation to the first socket surface and the first tang surface which are formed in proximity to the interior wall of the tank; and (c) shaping the socket and tang such that welding material deposited in the socket, upon being heated and upon being compressed by the socket and tang being forced together until the stop is reached, flows from the point of deposit in the socket away from the stop (toward the combination of the socket, the portion of the means for separating being secured and tang), to form an interior lap joint. All of these steps are once again preferably formed as part of steps 201 and 202 discussed hereinabove; but may be performed in separate process steps as well.

Further yet, according to a preferred embodiment of the invention, the first plastic tank section and the second plastic tank section are formed via an injection molding process; and the aforementioned manufacturing step of joining (step 204 referred to hereinabove) further comprises the steps of: (a) depositing a welding material (such as the aforementioned mixture of thermoplastic and metal particles) into the socket; (b) heating the welding material; and (c) compressing the heated welding material between the socket and tang until the stop is reached.

An alternative process for manufacturing an expansion tank, embodying the invention, is illustrated with reference to FIG. 6. The alternate process comprises the steps of: (a) fabricating a one piece molded plastic gas dome including an integrally formed socket, further including a sealing surface, and gas connection (step 301 in FIG. 6);(b) fabricating a one piece molded plastic water dome including an integrally formed tang and

water connection (step 302 in FIG. 6); (c) fitting a diaphragm onto the sealing surface of the socket (step 303 in FIG. 6); (d) depositing a welding material into the socket (step 304 in FIG. 6); (e) heating the welding material (step 305 in FIG. 6); and (f) compressing the heated welding material between the socket and tang until a stop formed by the socket and tang is reached (step 306 in FIG. 6).

As previously stated, the invention (as exemplified by the various embodiments thereof described hereinabove), features (when compared with the prior art described hereinbefore): (a) fewer parts; (b) fluid connections molded into the tank sections (domes) that when joined (the tank sections) form the containment vessel itself; (c) the use of plastic materials that do not require liners or seals; (d) a diaphragm (or bladder, etc.) captured between the domes; (e) a simplified set of production processes; (f) a tank that is corrosion resistant inside and out; (g) a tank that does not require outside finishing (e.g., painting) for finish protection; and (h) a reliable tank that can safely be utilized for a variety of applications including water storage applications and high pressure environments due to the inherent strength of the lap joint formed using the process described hereinbefore.

What has been described in detail hereinabove are methods, apparatus and fabrication techniques which meet all of the aforestated objectives. As previously indicated, those skilled in the art will recognize that the foregoing description has been presented for the sake of illustration and description only. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and obviously many modifications and variations are possible in light of the above teaching.

The embodiments and examples set forth herein were presented in order to best explain the principles of the instant invention and its practical application to thereby enable others skilled in the art to best utilize the instant invention in various embodiments and with various modifications as are suited to the particular use contemplated.

In view of the above it is, therefore, to be understood that the claims appended hereto are intended to cover all such modifications and variations which fall within the true scope and spirit of the invention.

Claims

1. A corrosion resistant expansion tank, comprising:

   (a) a first molded plastic tank section integrally including first connection means for enabling fluid from a first fluid source to be placed in fluid communication with a first interior portion of said expansion tank; and
   (b) a second molded plastic tank section, which when joined together with said first molded plastic tank section forms the expansion tank fluid containment vessel, integrally including second connection means for enabling fluid from a second fluid source to be placed in fluid communication with a second separate interior portion of said expansion tank.

2. Apparatus as set forth in claim 1 further comprising means for separating said expansion tank into said first interior portion and said second separate interior portion.

3. Apparatus as set forth in claim 2 wherein said means for separating spans the interior of said tank.

4. Apparatus as set forth in claim 2 or 3 wherein said means for separating is a flexible material.

5. Apparatus as set forth in claim 2, 3 or 4 wherein said means for separating is impermeable to a predetermined set of fluids including those fluids provided by said first fluid source and said second fluid source.

6. Apparatus as set forth in claim 2 further comprising means for securing said means for separating within said expansion tank in a joint formed between said first molded plastic tank section and said second molded plastic tank section.

7. Apparatus as set forth in claim 6 wherein said means for securing further comprises:

   (a) a socket, integrally formed in said first molded plastic tank section, for receiving:
   (b) a joint forming material, deposited into said socket during tank assembly, for use in joining said first molded plastic tank section to said second molded plastic tank section and securing said means for separating therebetween; and
   (c) a tang, integrally formed in said second molded plastic tank section, designed for insertion into said socket for use in joining said first molded plastic tank section and said second molded plastic tank section together to form the expansion tank fluid containment vessel.

8. Apparatus as set forth in claim 7 wherein said socket and said tang further comprise a first socket surface and first tang surface respectively, designed to accommodate the installation and securing of a portion of said means for separating therebetween.

9. Apparatus as set forth in claim 6 wherein said means for securing is operative to maintain the separation between said first interior portion and said separate second interior portion defined by said means for separating during both tank assembly

and tank operation.

10. Apparatus as set forth in claim 9 wherein said means for securing is further operative to hold said means for separating in place during and after precharging said tank with a prespecified amount of fluid pressure.

11. Apparatus as set forth in claim 1 wherein said first connection means provides a passageway through which fluid from said first fluid source may be introduced into and may be withdrawn from said expansion tank.

12. Apparatus as set forth in claim 1 wherein said second connection means provides a passageway through which fluid from said second fluid source may be introduced into and may be withdrawn from said expansion tank.

13. A corrosion resistant expansion tank, comprising:

(a) a first molded plastic tank section including a first tank connection integrally molded therein;
(b) a second molded plastic tank section, which when joined together with said first molded plastic tank section forms the expansion tank fluid containment vessel, including a second tank connection integrally molded therein;
(c) means for separating said tank into a first interior portion and a second interior portion, said means for separating being secured between said first molded tank section and said second molded plastic tank section; and
(d) means for securing said means for separating in a joint formed between said first molded tank section and said second molded plastic tank section.

14. Apparatus as set forth in claim 13 wherein said first molded plastic tank section further comprises a gas dome which may be connected to a gas source via said first tank connection integrally molded in said first molded plastic tank section, wherein said gas dome includes a sealing surface.

15. Apparatus as set forth in claim 14 wherein said second molded plastic tank section further comprises a water dome, designed to fit into said gas dome, which may be connected to a water source via said second tank connection integrally molded in said second molded plastic tank section.

16. Apparatus as set forth in claim 15 wherein at least a portion of said means for separating is formed to fit onto the sealing surface of said gas dome.

17. Apparatus as set forth in claim 16 wherein said portion of said means for separating is sealed between said gas dome and said water dome by fitting said portion of said means for separating into said sealing surface and then joining said gas dome and said water dome together to form a lap joint by compressing a material that includes a thermoplastic until a stop is reached.

18. Apparatus as set forth in claim 2 or 17 wherein said means, for separating includes a thermoplastic material.

19. Apparatus as set forth in claim 2 or 17 wherein said means for separating is a flexible diaphragm.

20. Apparatus as set forth in claim 2 or 17 wherein said means for separating is a flexible bladder.

21. Apparatus for securing, within an expansion tank, means for separating the interior of said tank into two separate portions, wherein said expansion tank is formed utilizing a first molded plastic tank section and a second molded plastic tank section that when joined together forms the expansion tank fluid containment vessel, comprising:

(a) a socket, integrally formed in said first molded plastic tank section, for receiving:
(b) a joint forming material, deposited into said socket during tank assembly, for use in joining said first molded plastic tank section to said second molded plastic tank section and securing said means for separating therebetween; and
(c) a tang, integrally formed in said second molded plastic tank section, designed for insertion into said socket for use in Joining said first molded plastic tank section and said second molded plastic tank section together to form the expansion tank fluid containment vessel, wherein said socket and said tang further comprise a first socket surface and first tang surface respectively, designed to accommodate the installation and securing of a portion of said means for separating therebetween.

22. Apparatus as set forth in claim 8 or 21 wherein said portion of said means for separating is shaped to facilitate the engagement of said portion of said means for separating with at least a portion of said first socket surface during tank assembly.

23. Apparatus as set forth in claim 22 wherein said socket and said tang further comprise a second socket surface and second tang surface respectively, which when juxtaposed form a stop.

24. Apparatus as set forth in claim 23 wherein said second socket surface and second tang surface are

located in proximity to the exterior wall of said tank in relation to the combination of said socket, said portion of said means for separating and said tang which is located toward the interior wall of said tank.

25. Apparatus as set forth in claim 8 or 24 wherein said joint forming material includes a thermoplastic.

26. Apparatus as set forth in claim 8 or 24 wherein said joint forming material is a welding material which flows upon being heated.

27. Apparatus as set forth in claim 26 wherein said welding material further comprises a mixture of thermoplastic and metal particles.

28. Apparatus as set forth in claim 26 wherein said socket and tang are designed such that weld material deposited in said socket, upon being heated and upon being compressed by said socket and said tang being forced together until said stop is reached, flows from the point of deposit in said socket away from said stop and toward said combination of said socket, said portion of said means for separating and said tang, to form an interior lap joint.

29. Apparatus as set forth in claim 28 wherein said interior lap joint forms a weld that joins said tang and said socket, together.

30. Apparatus as set forth in claim 28 wherein said interior lap joint forms a weld that joins said tang, said socket and said means for separating, together.

31. Apparatus as set forth in claim 28 wherein said interior lap joint when reheated is separable to enable said tank to be taken apart.

32. Apparatus as set forth in claim 8 or 21 wherein at least a portion of said first tang surface is roughened to enhance the ability of said means for securing to secure said portion of said means for separating between said first tang surface and said first socket surface.

33. An expansion tank comprising:

(a) a first plastic tank section forming a first interior portion;
(b) a second plastic tank section forming a second interior portion;
(c) a welded joint between said first and second tank sections;
(d) means for separating said expansion thank into said first and second separate interior portions wherein said means for separating is secured in said welded joint between said first and second tank portions.

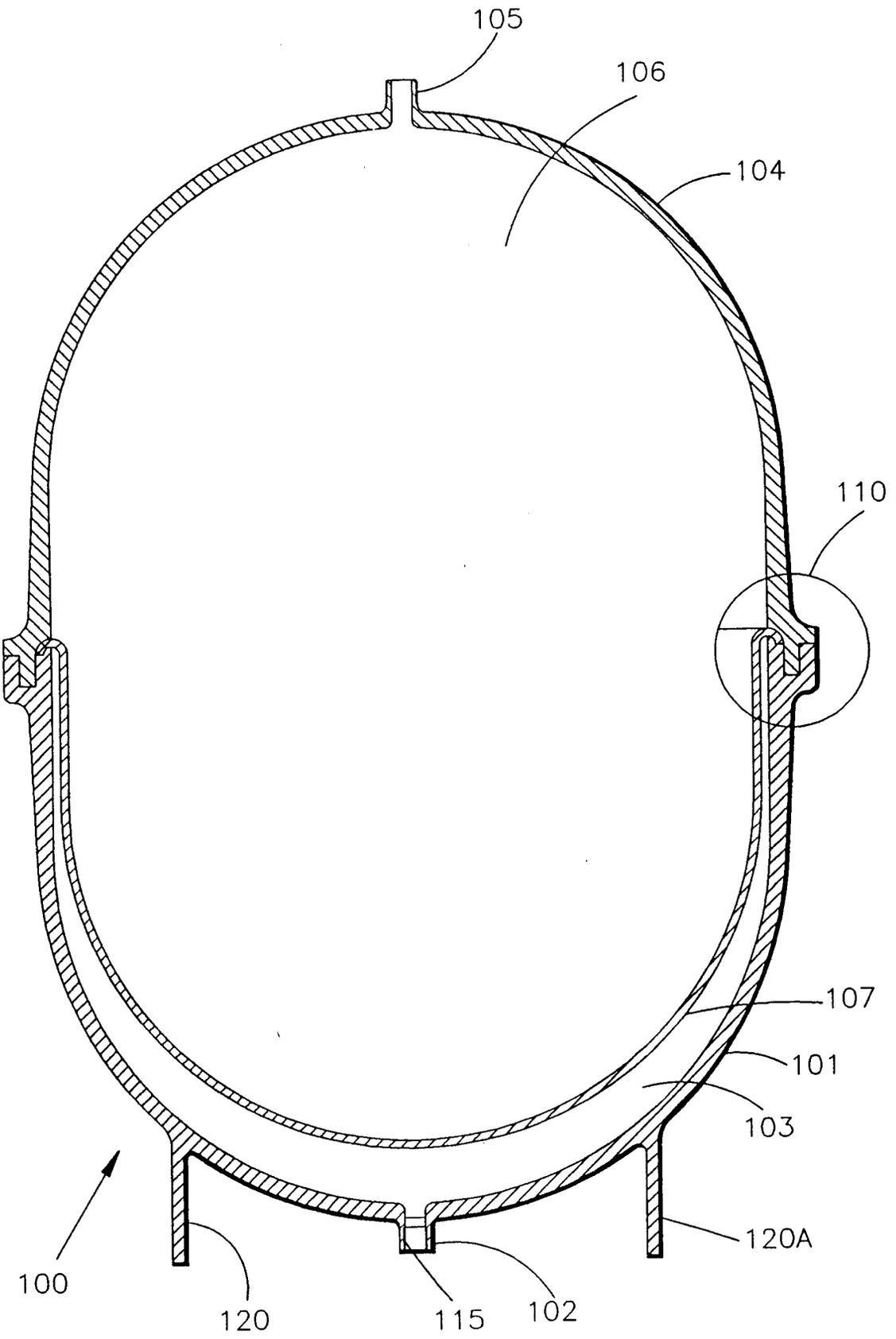

FIG. 1

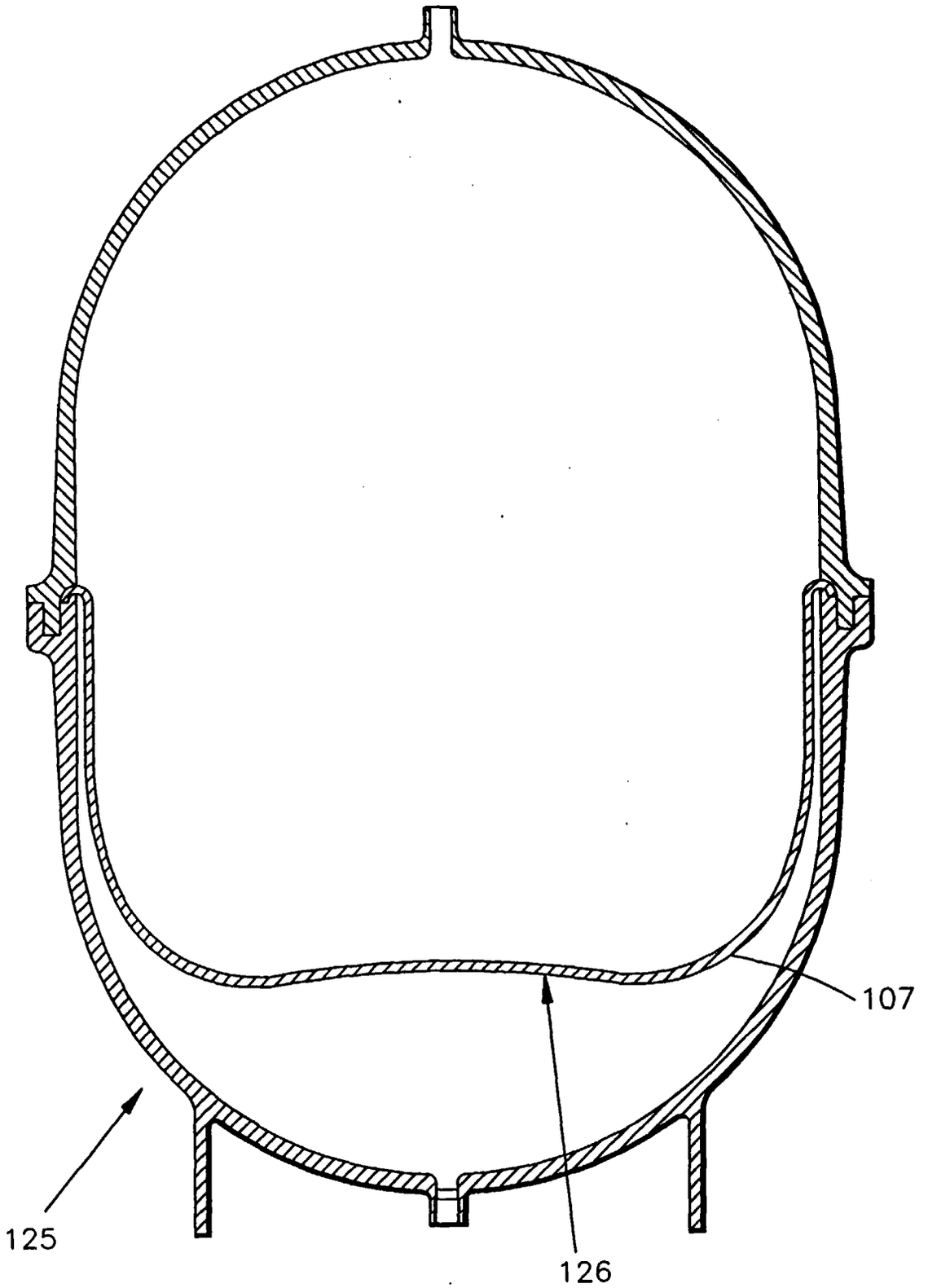

FIG. 1A

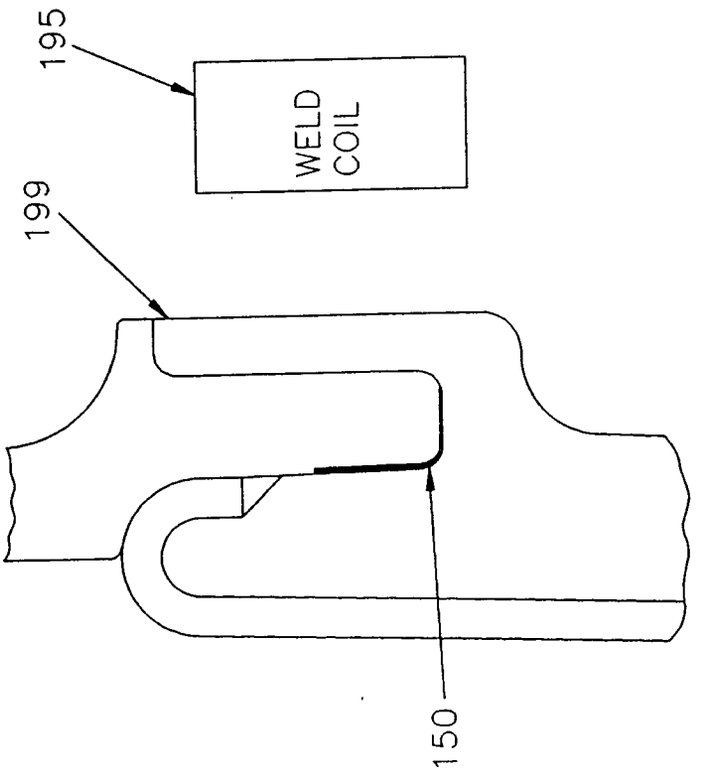
195
WELD COIL
199
150

FIG. 3

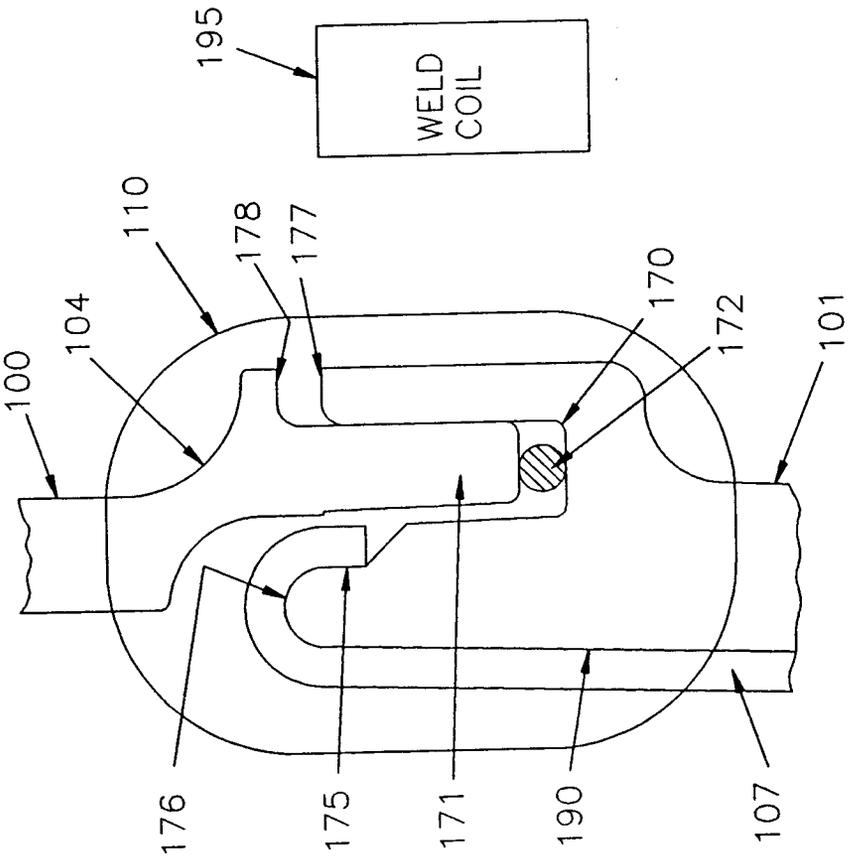
195
WELD COIL
110
178
177
104
100
170
172
101
176
175
171
190
107

FIG. 2

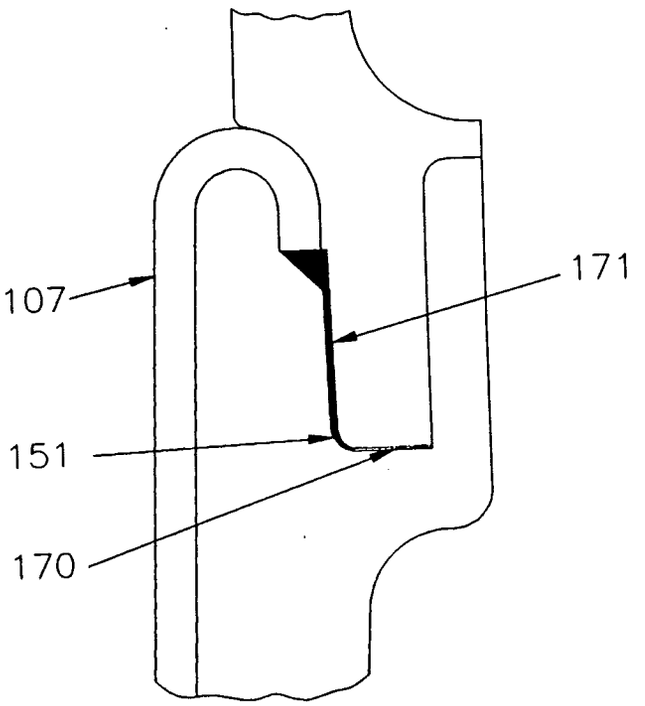

FIG. 3A

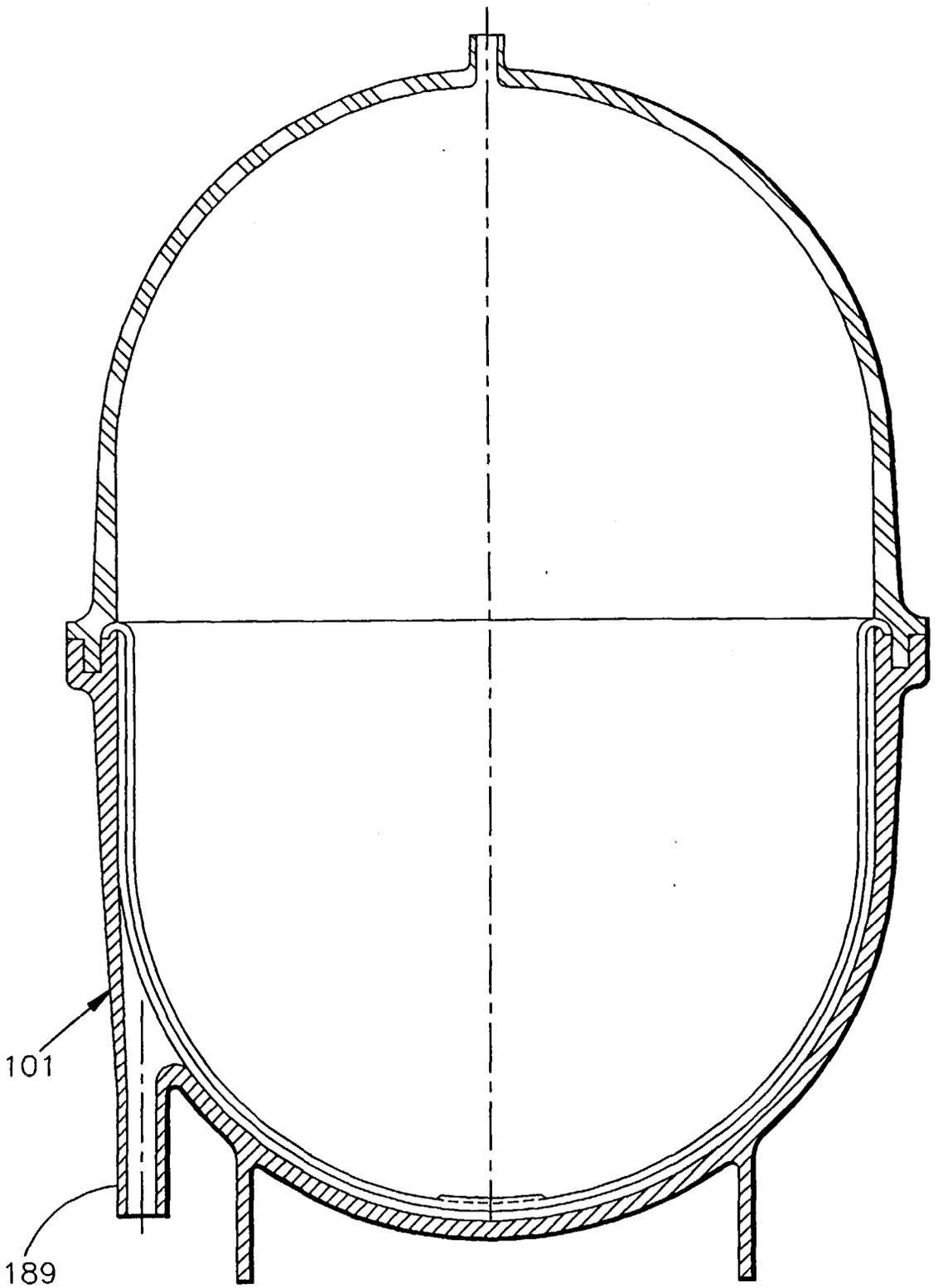

FIG. 4

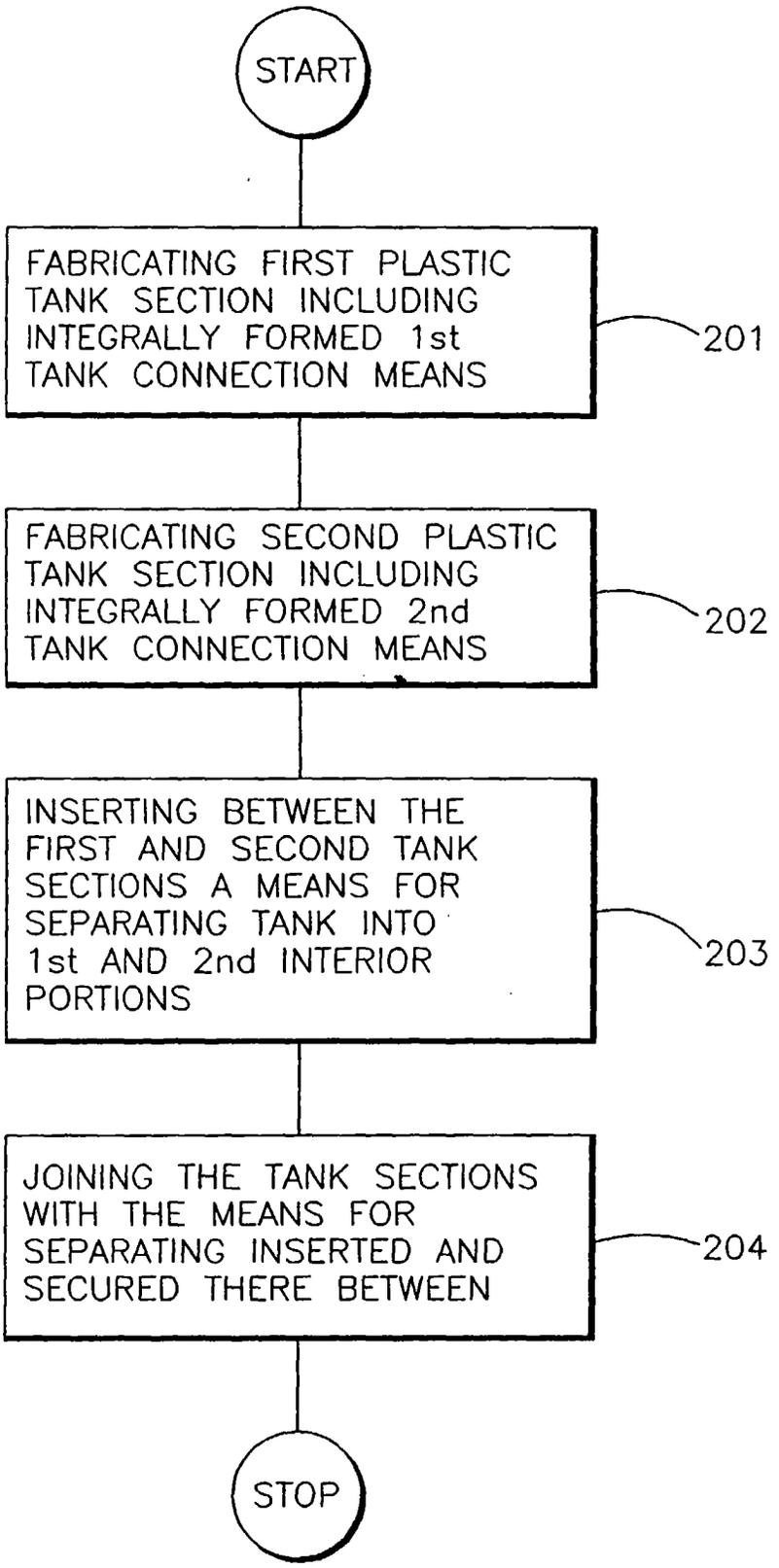
START
FABRICATING FIRST PLASTIC TANK SECTION INCLUDING INTEGRALLY FORMED 1st TANK CONNECTION MEANS
201
FABRICATING SECOND PLASTIC TANK SECTION INCLUDING INTEGRALLY FORMED 2nd TANK CONNECTION MEANS
202
INSERTING BETWEEN THE FIRST AND SECOND TANK SECTIONS A MEANS FOR SEPARATING TANK INTO 1st AND 2nd INTERIOR PORTIONS
203
JOINING THE TANK SECTIONS WITH THE MEANS FOR SEPARATING INSERTED AND SECURED THERE BETWEEN
204
STOP

FIG. 5

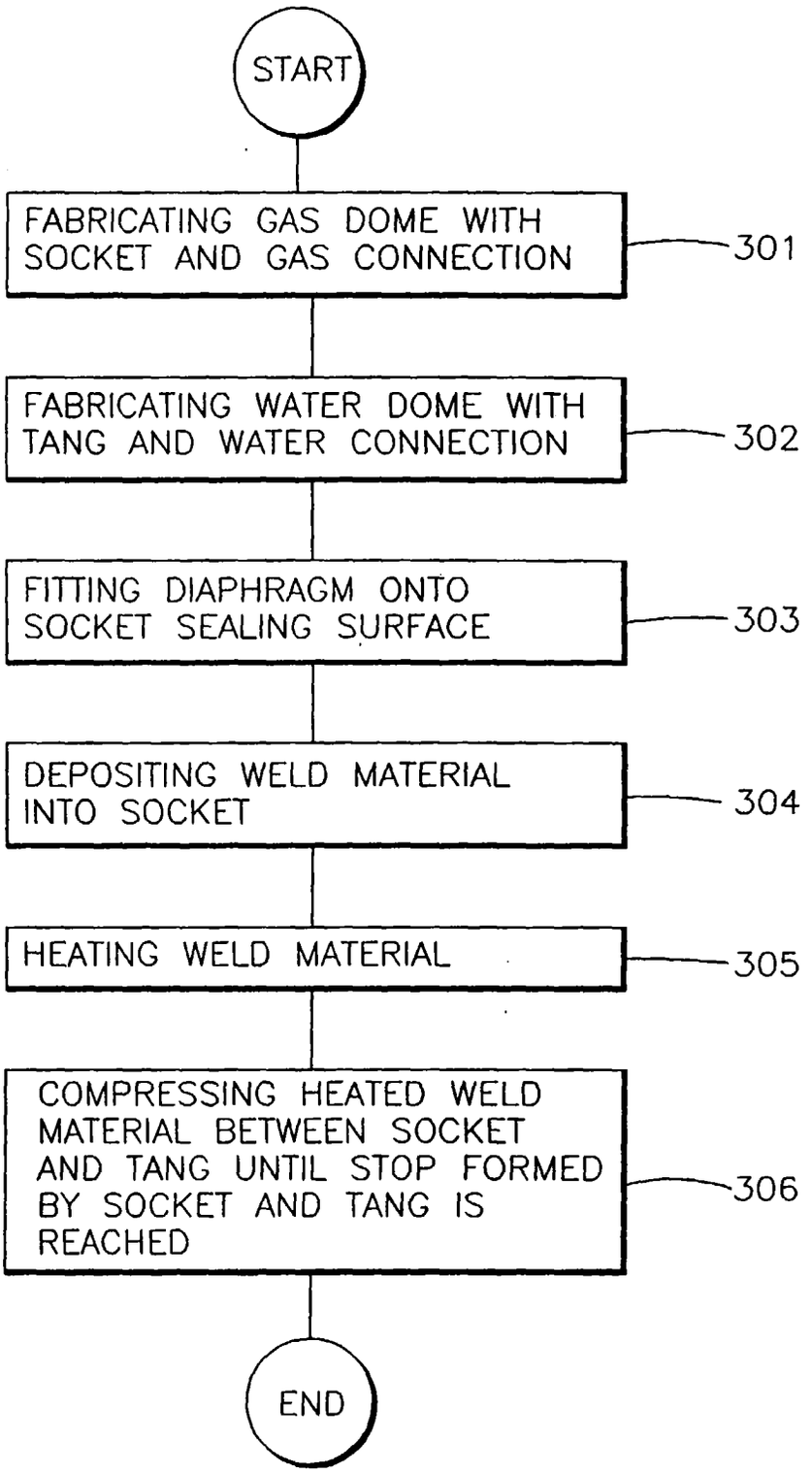
START
FABRICATING GAS DOME WITH SOCKET AND GAS CONNECTION
301
FABRICATING WATER DOME WITH TANG AND WATER CONNECTION
302
FITTING DIAPHRAGM ONTO SOCKET SEALING SURFACE
303
DEPOSITING WELD MATERIAL INTO SOCKET
304
HEATING WELD MATERIAL
305
COMPRESSING HEATED WELD MATERIAL BETWEEN SOCKET AND TANG UNTIL STOP FORMED BY SOCKET AND TANG IS REACHED
306
END

FIG. 6

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 5147

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
X	DE 295 11 961 U (LIN CHING HSIUNG) 28 September 1995 * page 2, line 10-20 * * page 3, line 4-11; figures *	1-6, 9-16, 18-20,33	F15B1/12 F17C1/16
A	---	25,27	
X	US 5 383 566 A (JOHNSON TERENCE C) 24 January 1995 * column 3, line 19-54; figures *	1-3,5-9, 11-18, 21,22	

X	US 4 437 590 A (LABRUNA ANTHONY J) 20 March 1984 * figures *	1-8, 11-13, 21-23,26	
A	---	25	
X	DE 20 29 457 A (LANGEN & CO) 23 December 1971 * figure *	21-24,26	
A	---	25,28-32	
A	US 4 579 242 A (ELLIS III GEORGE S) 1 April 1986 * column 2, line 50-65; figures *	21, 25-27,31	

A	US 4 982 856 A (STOKES VIJAY K) 8 January 1991 * column 9, line 3-21; figures 1A-4B *	21,23, 25-31	

A	US 3 454 179 A (KERR RAYMOND W) 8 July 1969 * column 4, line 47-52 * * column 5, line 21-48; figures *	21,25-28	

	-/--		

TECHNICAL FIELDS SEARCHED (Int.Cl.6)
F16J
F24D
F17C
F15B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	21 May 1997	Pöll, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 96 30 5147

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	FR 2 266 019 A (OLAER PATENT CO) 24 October 1975 * page 3, line 21-25; figure * ---	18	
A	DE 40 08 026 A (OTTO GEB KG) 12 September 1991 * column 3, line 18-24; figure 1 * -----	32	
			TECHNICAL FIELDS SEARCHED (Int.Cl.6)

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	21 May 1997	Pöll, A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)