EXPANSION TANK WITH IMPROVED SINGLE DIAPHRAGM

BACKGROUND OF THE INVENTION

Expansion tanks are known for use in flow systems for controlling flow of liquid under varying pressures. Most commonly, expansion tanks comprise a substantially cylindrical housing terminated on each end by a substantially hemispherical dome section. The entire combined tank being most preferably suitable for isotensoidal reinforcement by wrapping with equally stressed filaments. In some cases, the cylindrical housing may be shortened or absent, such that the entire shape is spherical, comprised of the two domes. The housing and domes further contain a bladder-type diaphragm that divides areas of a liquid and a pressurized gas. For a general discussion of expansion tanks and bladder-type diaphragms, see U.S. Pat. No. 4,784,181 to Hilverdink entitled "Expansion Tank with a Bladder-Type Diaphragm".

In expansion tanks, it is critical to maintain a liquid and gas-tight barrier between the liquid and pressurized gas, as well as the outside environment. Any leakage between gas and liquid, or gas and outside, will cause the tank to stop working until it is recharged and may also cause permanent damage to the tank. This gas tight barrier must also be capable of flexing and bending, while maintaining its integrity through continuous changes in temperature and pressure, making material selection and seal joint design an integral part of overall tank performance.

Two general approaches to making this barrier have traditionally been used. For example, a first approach, as described in, among others, U.S. Patent 7322488, and 7303091, "Expansion tank with double diaphragm", includes a "double diaphragm bladder" secured to the interior of a tank. The bladder comprises a non-flexible diaphragm having a peripheral edge and a flexible diaphragm having a peripheral edge. The peripheral edges of the non-flexible diaphragm and the flexible diaphragm are sealed together with a ring clamp, or by heat sealing. This provides an excellent leak-proof seal. Most important in this design, the movement of the diaphragm in operation is decoupled from the outer, cylindrical housing and domes. Therefore, when the pressure differential between the water and air sections of the tank changes, and the diaphragm moves or is stretched, it does not pull on the walls of the cylinder. This approach, however has the disadvantage that it uses additional parts, including the large non-flexible diaphragm, along with corresponding additional fabrication steps, which adds both materials and manufacturing costs when compared to the second approach.

The second approach to the air-water barrier that is generally used is described in US patents 7,671,754 Sensor for detecting leakage of a liquid; 5,368,073 Hydro pneumatic Pressure Vessel Having an Improved Diaphragm Assembly;5,484,079 Hydro pneumatic Filament Wound Pressure Vessel; and 7,216,673 Non Metallic Expansion Tank With Internal Diaphragm and Clamping Device for Same. In this design, the diaphragm is directly coupled to the outer wall of the dome or cylindrical housing by either adhesive bonding or a mechanical clamping mechanism. While this second approach has a reduced number of parts compared to the first approach that was described, attaching the diaphragm directly to the wall of the tank is a fundamentally flawed design: as the pressure differential between the water and air sections of the tank changes and the diaphragm moves and stretches, the diaphragm pulls on the attachment point to the vessel wall. It is well known by those skilled in the art that thin-walled, large diameter cylinders and spheres are very poor in collapse conditions; by pulling inwards on the wall of the tank, it is possible to collapse portions of the tank construction. Just as importantly, it is well known by those skilled in the art that the bond strength between the dissimilar materials of construction of the tank can be very low; the force exerted by the diaphragm on the tank can cause delamination between different layers, such as the diaphragm (which is, typically, an elastomer or flexible thermoplastic), the outer wall (which is, typically, a rigid thermoplastic shell), or the fiber reinforcement (which is, typically, fiberglass in a thermoset). It can also cause interlaminar failure of the fiber reinforcement itself. So, by coupling the diaphragm directly to the wall, permanent, catastrophic failure of the tank can result.

SUMMARY OF THE INVENTION

In this invention, expansion tanks with two novel improvements to the diaphragm seal are disclosed. Both improvements allow for robust seals to be fabricated with improved processing and manufacturing flexibility.

The first improvement is a diaphragm coupling ring. The diaphragm coupling ring is a discrete part of the diaphragm tank that can be fabricated independent of the domes and cylinder. The diaphragm coupling ring is specifically designed to provide a robust, leak-proof seal with the diaphragm, and then be connected to the expansion tank in a separate, secondary operation. The coupling ring being an independent part of the construction, it can be initially joined with the diaphragm using conditions, equipment, and processes that are not compatible with existing expansion tank manufacturing, before being joined into the tank.

The second improvement is the novel application of "tie-layers" to join the dissimilar materials of the diaphragm and the tank sections, e.g., the domes or the cylinder, the diaphragm and the coupling ring. Known processes to attach diaphragms to tanks only produce adhesion between the diaphragm and the surface layers of the tank wall; these joints are highly susceptible to adhesive failures under the operating conditions of expansion tanks. But with unique combinations of tie-layers with suitable manufacturing steps, the inventors disclose a process to produce a cohesive, covalent-, chemically- and/or thermally-bonded diaphragm that is ideally suited for the operating conditions of expansion tanks.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic cross-section diagram of a diaphragm tank according to an embodiment of the coupling ring invention, representing the tank charged with air pressure, but not with water;

FIG. 1B is an expanded schematic cross-section view of a portion of the diaphragm tank and coupling ring of FIG 1;

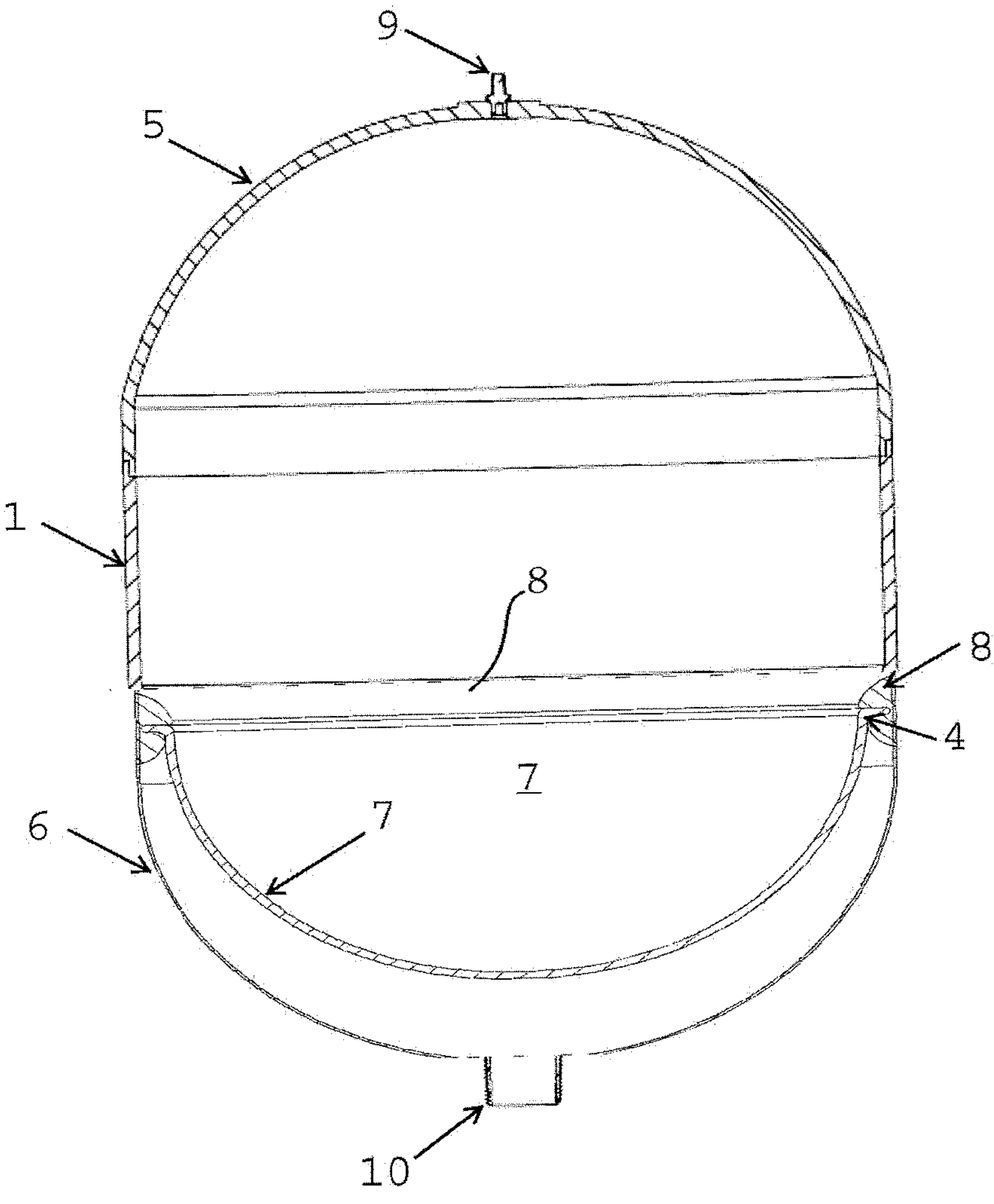

FIG. 1

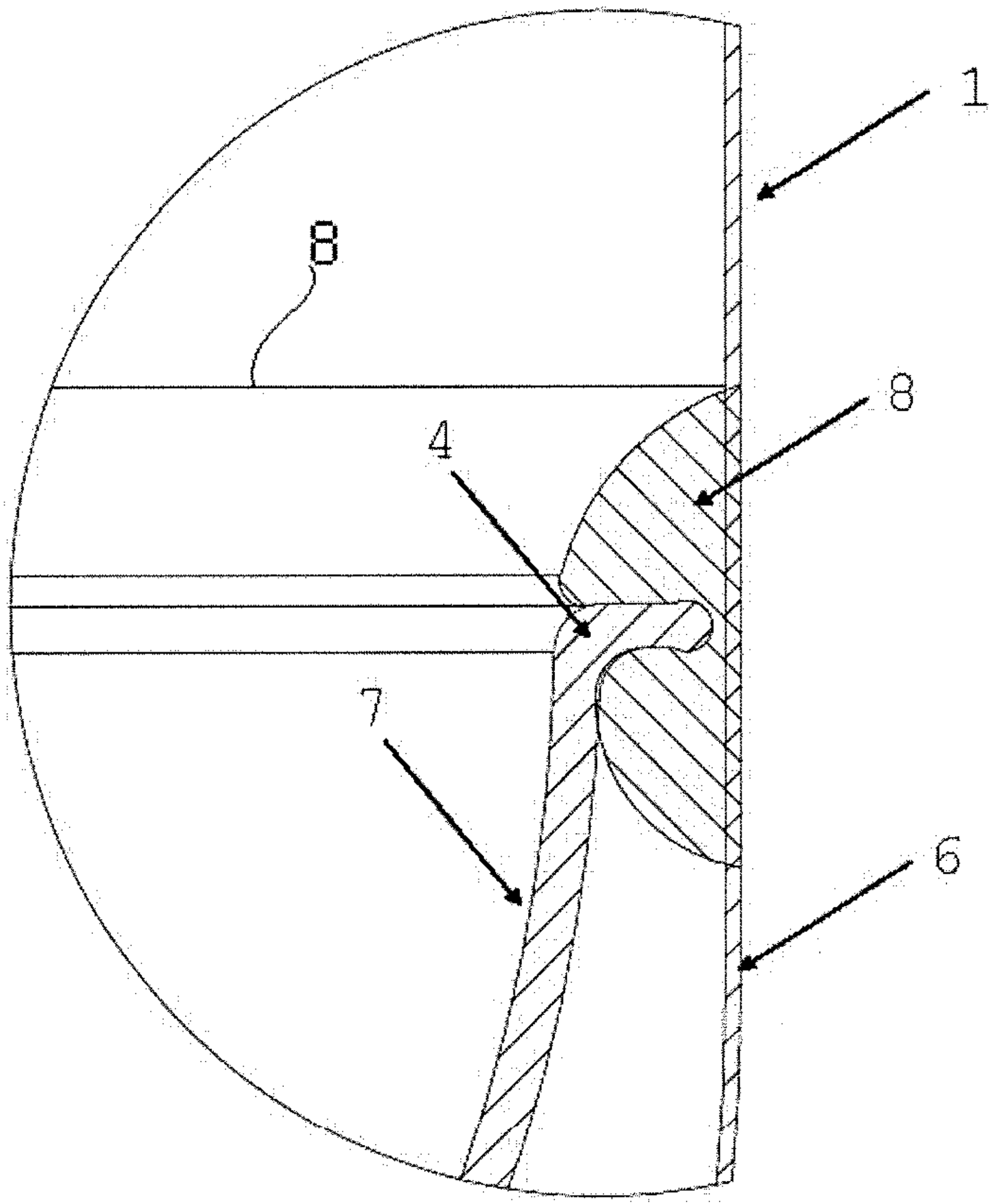

FIG. 1B