UNITED STATES PATENT AND TRADEMARK OFFICE

Utility Patent Application (Provisional)

TITLE: LIGHTWEIGHT AND COST-EFFECTIVE PRESSURE EQUALIZATION SYSTEM FOR DEEP-SEA APPLICATIONS

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FIELD OF THE INVENTION

[0001] The present invention pertains to the field of subsea equipment. This extensive category includes various types of machinery, structures, devices, and systems designed for underwater applications, often for exploration or exploitation of the resources found within marine environments.

[0002] More specifically, it is related to the design and implementation of pressure equalization systems utilized in these devices to counteract the pressures encountered in deep-sea environments. These systems are crucial in maintaining the integrity and function of underwater devices when subjected to the immense pressures found in deep oceanic conditions.

[0003] Subsea devices and equipment are deployed across various industries, each with unique requirements and conditions. Such industries include, but are not limited to, oil and gas exploration, marine biology research, naval operations, undersea telecommunications, salvage operations, and archaeological studies.

[0004] In these applications, the equipment is required to operate under extreme pressures, often reaching several thousand pounds per square inch (psi). As the depth increases, the pressure levels also rise proportionally, challenging the durability and resilience of subsea equipment.

BACKGROUND OF THE INVENTION

[0005] Given the formidable pressures in deep-sea environments, there is a persistent engineering challenge to maintain structural integrity and operational functionality of subsea equipment. The escalating pressure levels can potentially cause deformation, fracture, and functional failure of various components within the equipment.

[0006] Traditional solutions to these challenges include enveloping sensitive components in heavy, thick-walled casings or submerging them in a protective medium like oil. These methods are aimed at shielding the enclosed components from the external pressure, acting as a buffer.

[0007] However, both solutions have inherent limitations. Oil submersion isn't suitable for all devices, particularly those with moving parts or sensitive sensors. These parts may malfunction when in contact with oil, leading to operational issues. Thick casings, while robust, add considerable weight and cost to the equipment due to the specialty materials and manufacturing techniques required.

[0008] Another solution involves the use of passive compressors, such as air-filled cylinders. These systems adjust and equalize the internal compartment pressure as the equipment descends. The pressure within these cylinders changes dynamically, mirroring the external pressure to maintain an equilibrium.

[0009] Despite their effectiveness, these systems are also heavy and costly, making them an impractical solution for many applications. They add substantial weight and volume to the equipment, affecting mobility and efficiency. Furthermore, their construction demands high-strength materials and complex manufacturing procedures, escalating the overall cost.

[0010] Therefore, there is a continuous demand for a cost-effective, lightweight, and efficient solution to maintain and manage pressure differences between the interior of the subsea equipment and the surrounding high-pressure deep-sea environment. This demand arises from the constant need for more durable, resilient, and efficient subsea equipment for increasingly demanding applications.

[0011] The present invention seeks to address this demand by introducing an innovative and superior pressure equalization system for deep-sea applications that improves upon traditional designs and overcomes the limitations of existing technologies. This system is designed to offer a more practical, cost-effective, and lightweight solution for managing extreme pressures, offering potential benefits in a variety of underwater applications.

SUMMARY OF THE INVENTION

[0012] The present invention seeks to provide an innovative pressure equalization system using a standard high-pressure tank fitted with an airtight latex liner. The system is lightweight, cost-effective, and capable of equalizing pressure effectively even at full ocean depth, thus enhancing the durability and functionality of electronic devices which require operation in air environments.

DETAILED DESCRIPTION OF THE INVENTION

[0013] The inventive system comprises a standard high-pressure tank and an airtight latex liner fitted within the tank. This tank is designed to withstand high pressure up to 3000 psi, making it suitable for deep-sea applications. The latex liner serves as the compressive component, adjusting its volume according to the changing internal and external pressures. This dual-component assembly ensures a robust, yet flexible, system capable of withstanding deep-sea pressures while providing efficient pressure equalization.

[0014] The high-pressure tank features two valves, one on each end. The first valve opens into the tank itself, allowing for the filling and emptying of the tank's primary space. This valve allows for the external water pressure to enter the tank and compress the liner. The second valve opens into the latex liner, designed to pressurize the liner's interior to 3000 psi before use. This pre-pressurization provides the baseline pressure for the system and prepares it for further pressurization as the subsea vehicle descends. This valve is the output valve that sends the high pressure air to the electronics compartment.

[0015] A proprietary passive air regulator forms a critical part of the system. As the vehicle descends, the pressure increases, necessitating pressure equalization within the electronics compartment. The air regulator works continuously to match the internal pressure of the electronics compartment with the external sea pressure, thus protecting the enclosed electronic components from the extreme pressures they would otherwise face.

[0016] Once the subsea vehicle descends to a depth where the external pressure equals the tank pressure of 3000 psi, a secondary equalizer valve opens the other end of the tank. This ingenious design allows water to enter the tank, acting against the latex liner. The incoming water compresses the latex liner further, pushing the air inside it to

equalize the pressure within the electronics compartment. This process allows for the continuation of pressure equalization even beyond the initial 3000 psi limit.

[0017] One of the most notable features of the invention is its ability to compress a large volume of air to withstand full ocean depth pressures using a relatively small high-pressure tank. More specifically, it can compress a 1 liter air compartment to a pressure equivalent of 16000 psi using only a standard 6-liter tank. This powerful compression ratio underscores the system's ability to sustain pressure equalization in deep-sea environments, thereby enabling the use of thin, cost-effective casings for electronic components.

[0018] Furthermore, these thin, lightweight casings reduce the overall weight and cost of the subsea equipment without compromising the devices' integrity and functionality at full ocean depth. In effect, the system proposed in this invention provides a novel and efficient way of protecting electronic components in deep-sea environments, extending their useful lifespan and contributing to more reliable and economical subsea operations.

[0019] In summary, the inventive system introduces an advanced pressure equalization solution for deep-sea applications, leveraging a standard high-pressure tank, an airtight latex liner, and a unique valve and regulator setup. Its lightweight and cost-effective design, coupled with its exceptional performance capabilities, addresses several limitations associated with conventional pressure equalization methods. As such, it holds significant potential for a wide range of deep-sea applications, including research, exploration, and resource extraction.

INCLUDED FIGURES

[0020] Some properties of the current invention are provided below for exemplary and illustrative purposes and do not limit the precise specifications of the invention but rather serve as a reference for general attributes.

[0021] FIG. 1 - Figure 1 depicts a simplified plumbing diagram showing the base parts of the compressor system and how they relate to one another. In this figure one can see: the tank / environment pressure equalizer, a prefilter, the tank, the tank / casing pressure equalizer, and the casing.

[0022] FIG. 2 - Figure 2 depicts the tank compressor component and its relative parts. Included within the figure is a sectional diagram with sub component markings. Within this figure one can see: the tank, two DIN valves one as an input and one as an output, and the latex liner in both the compressed and expanded configuration.

[0023] FIG. 3 - Figure 3 depicts the equalizer valve in two states: the open and closed conditions. In this figure there are included notes as to the function of each port within the valve assembly.

[0024] FIG. 4 - Figure 4 depicts the equalizer valve assembly. In this diagram several angles and a sectional drawing are provided. The base components are also labeled. These include: the valve piston, the various ports, the seals and wipers, the casing body components.

CLAIMS

1. A pressure equalization system for subsea equipment, comprising:
   - a high-pressure tank designed to hold a specified pressure;
   - an airtight latex liner within the tank;
   - a first valve and a second valve, each placed at one end of the tank, wherein the first valve provides access to the tank and the second valve provides access to the latex liner.

2. The system of claim 1, wherein the specified pressure is up to 3000 psi.

3. The system of claim 1, wherein the latex liner is pre-pressurized to the specified pressure prior to usage.

4. The system of claim 1, further comprising a passive air regulator that automatically equalizes the pressure within an electronics compartment during descent in a body of water.

5. The system of claim 4, wherein the passive air regulator operates in response to changes in the external pressure of the surrounding water.

6. The system of claim 1, further comprising a secondary equalizer valve that, when activated, enables the surrounding water to compress the latex liner.

7. The system of claim 6, wherein the secondary equalizer valve is activated when the external water pressure matches the specified pressure of the high-pressure tank.

8. The system of claim 1, wherein the pressure equalization system is capable of compressing a specific volume of air to a pressure corresponding to the depth of the ocean using a tank of a predetermined volume.

9. The system of claim 8, wherein the specific volume of air is one liter, the pressure corresponding to the depth of the ocean is 16000 psi, and the predetermined volume of the tank is six liters.

10. The system of claim 1, wherein the pressure equalization system allows the use of thin and cost-effective casings for housing electronic components, withstanding external pressures equivalent to full ocean depth.

ABSTRACT

[0025] The present invention introduces an innovative pressure equalization system for subsea equipment designed to manage extreme pressures encountered in deep-sea environments. The system utilizes a standard high-pressure tank with an airtight latex liner, where one valve opens into the tank and the other into the liner. Before use, the liner side valve is pressurized, and as the vehicle descends, a proprietary passive air regulator continuously equalizes the electronics compartment. When reaching a depth where the pressure equates to the tank pressure, a secondary equalizer valve opens the other end of the tank, allowing water to compress the liner and maintain equalization beyond the initial pressure limit. This design enables a lightweight, cost-effective pressure equalizer capable of compressing air up to 16000 psi using only a 6-liter tank. Consequently, it provides the opportunity for the electronic air casing to be thinner and lower cost, even at full ocean depth, revolutionizing the deployment of subsea equipment in extreme environments.

FIGURE DOCUMENT ATTACHMENTS

FIG. 1

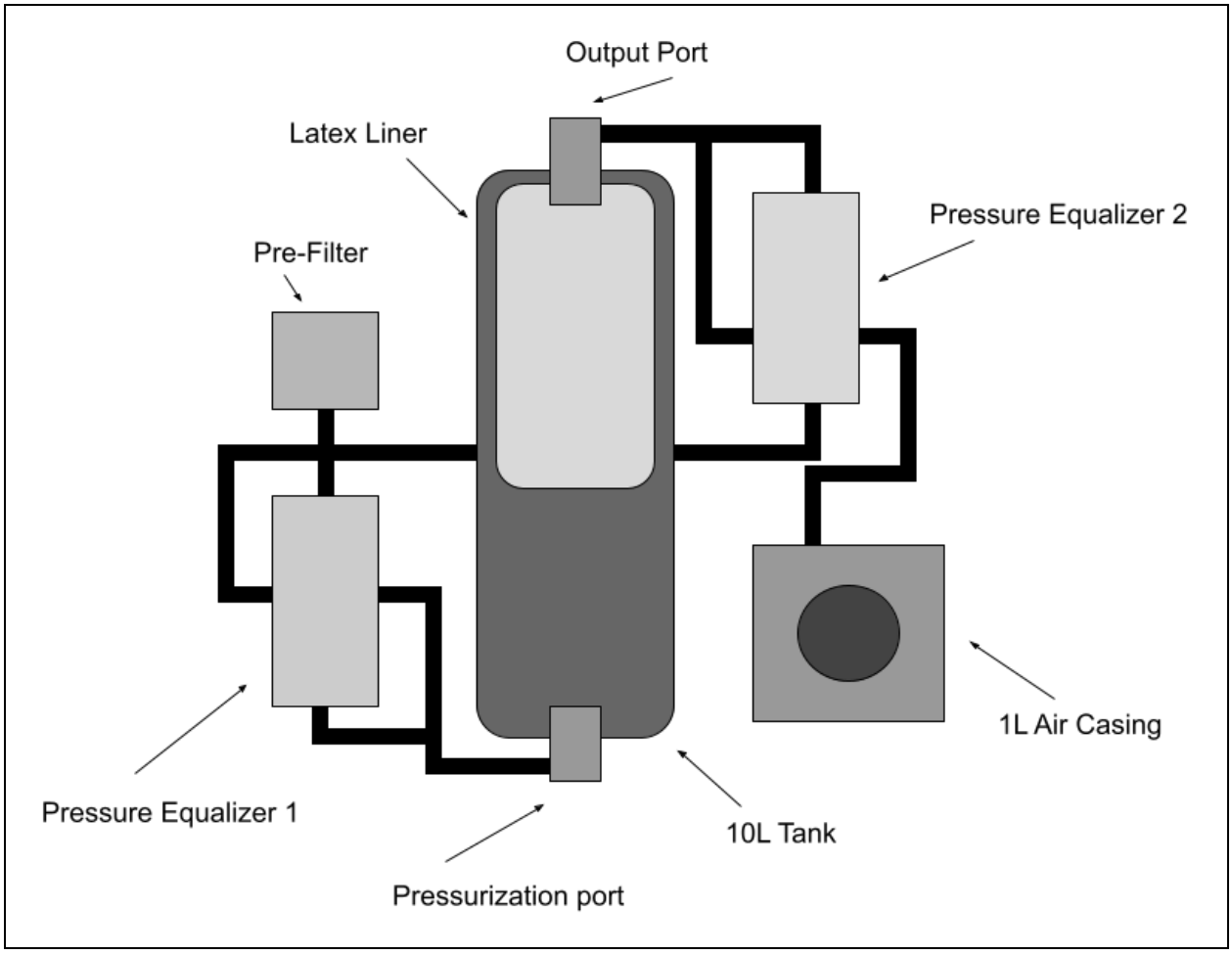
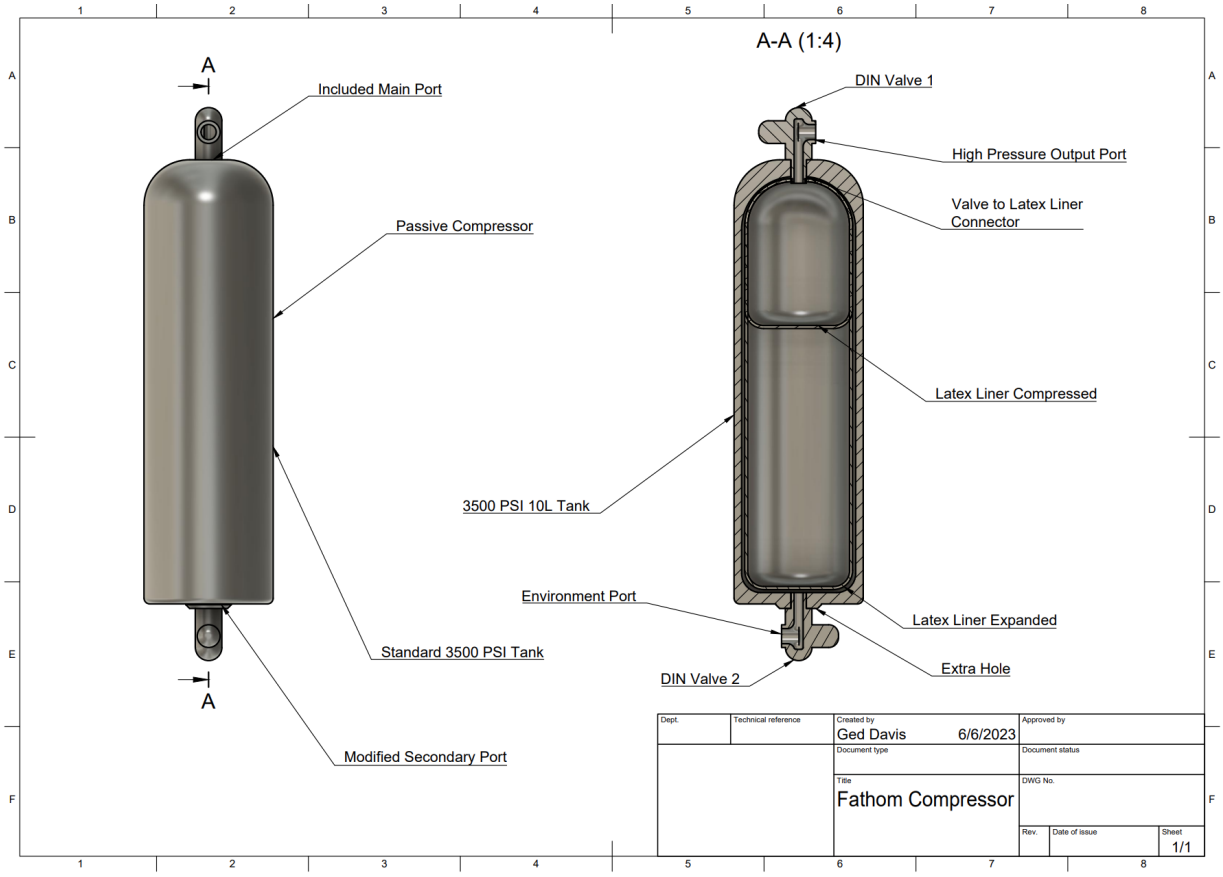


FIG. 2


A-A (1:4)
A
A
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Standard 3500 PSI Tank
Modified Secondary Port
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High Pressure Output Port
Valve to Latex Liner Connector
Latex Liner Compressed
3500 PSI 10L Tank
Environment Port
Latex Liner Expanded
Extra Hole
DIN Valve 2
Dept.
Technical reference
Created by
Ged Davis
6/6/2023
Approved by
Document type
Document status
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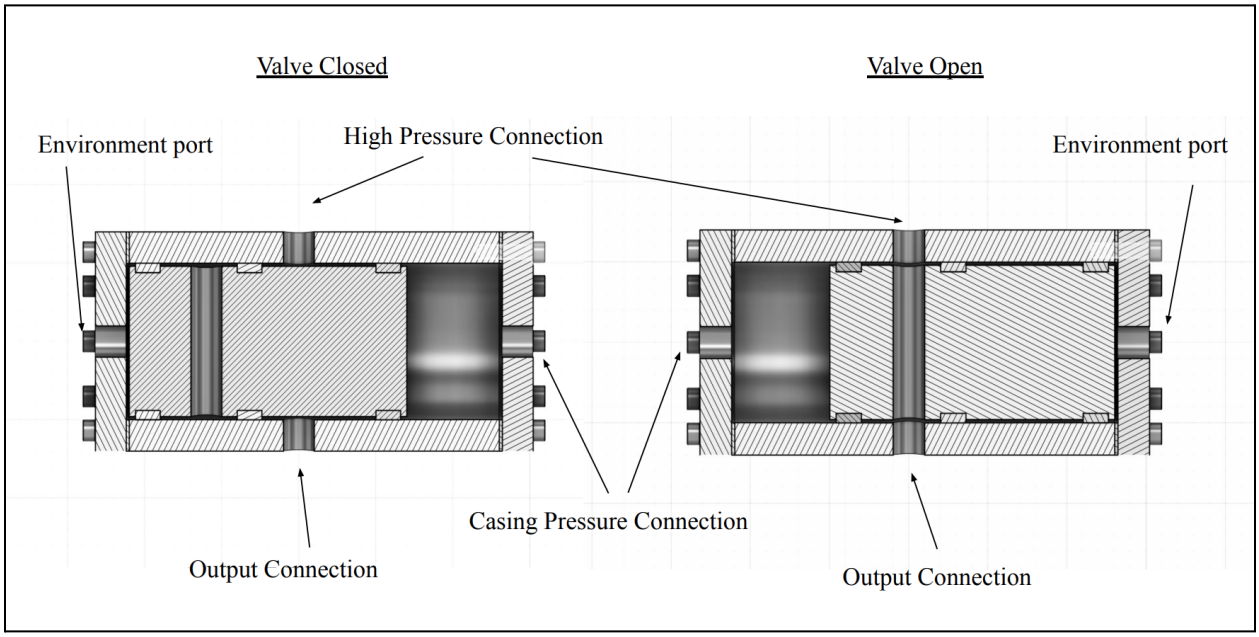
Rev.
Date of issue
Sheet
1/1

FIG. 3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Valve Open
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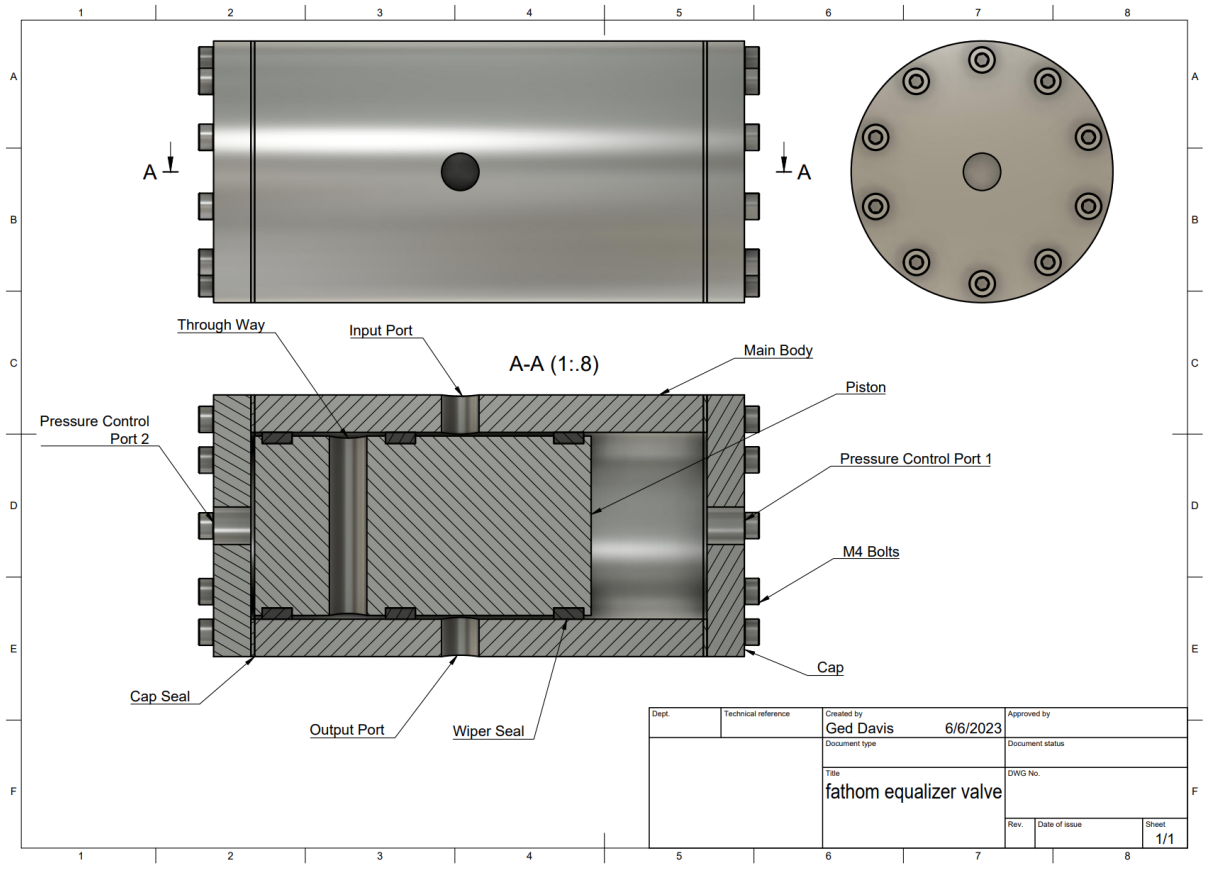
High Pressure Connection
Environment port
Casing Pressure Connection
Output Connection
Output Connection

FIG. 4


A
A
A-A (1:.8)
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Main Body
Piston
Pressure Control Port 2
Pressure Control Port 1
M4 Bolts
Cap
Cap Seal
Output Port
Wiper Seal
Dept.
Technical reference
Created by
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6/6/2023
Approved by
Document type
Document status
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Rev.
Date of issue
Sheet
1/1