

United States

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[54] MULTIELEMENT WINDOW

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[58] Field of Search 350/179, 180, 319

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Primary Examiner—John K. Corbin

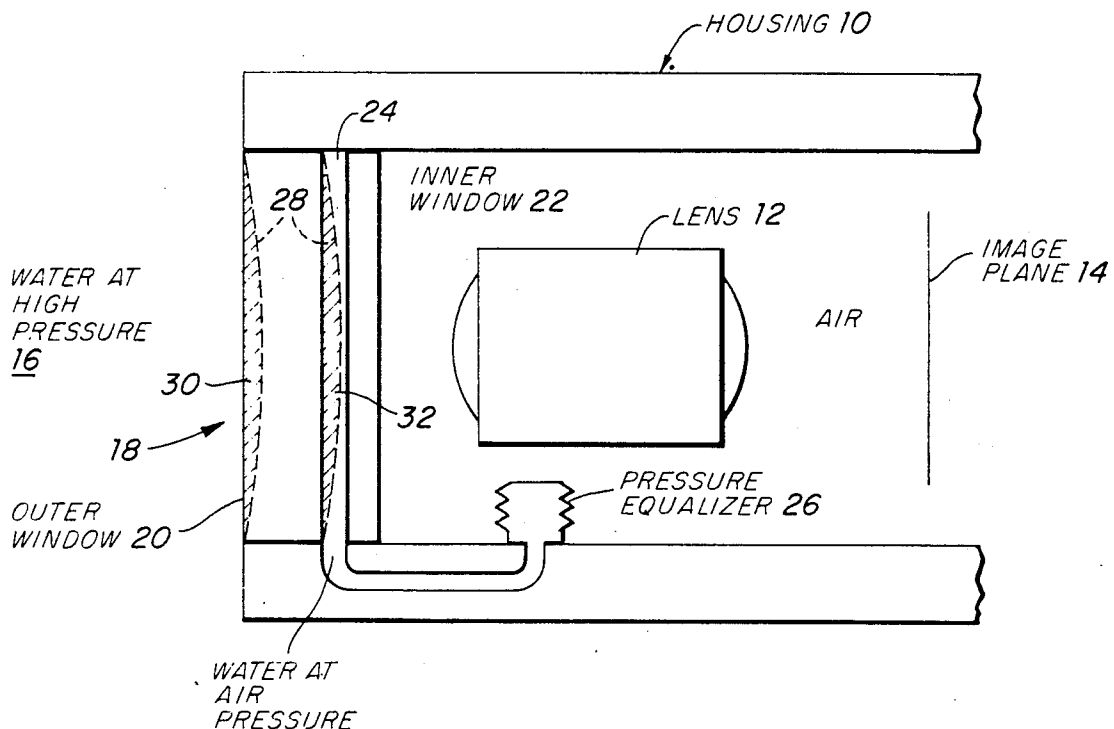
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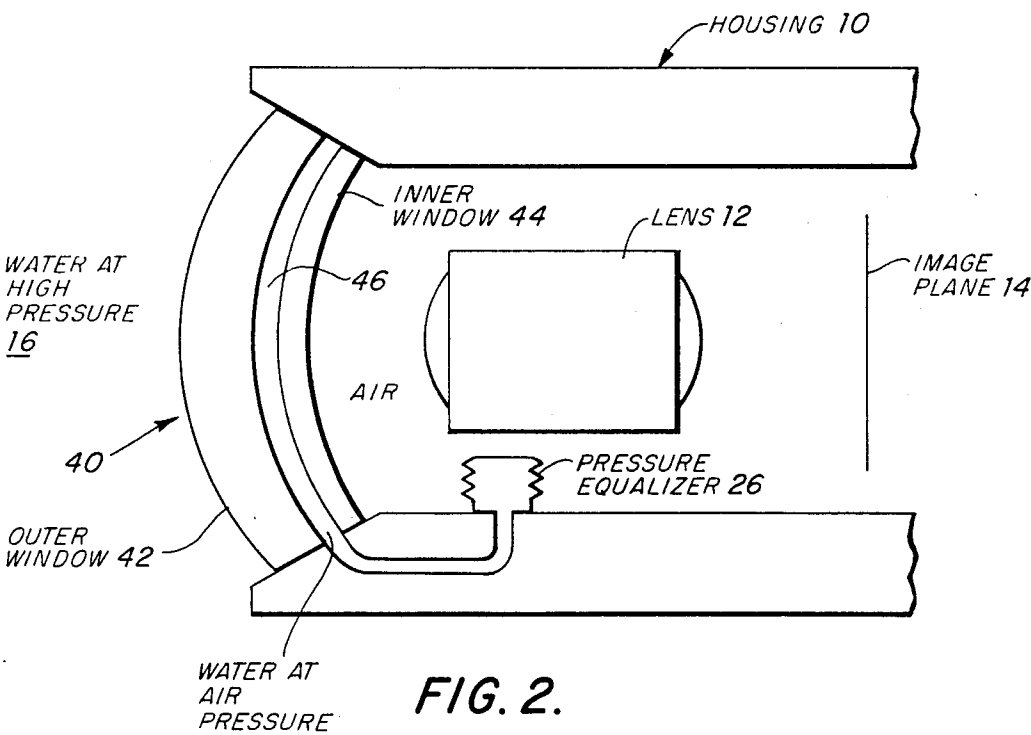
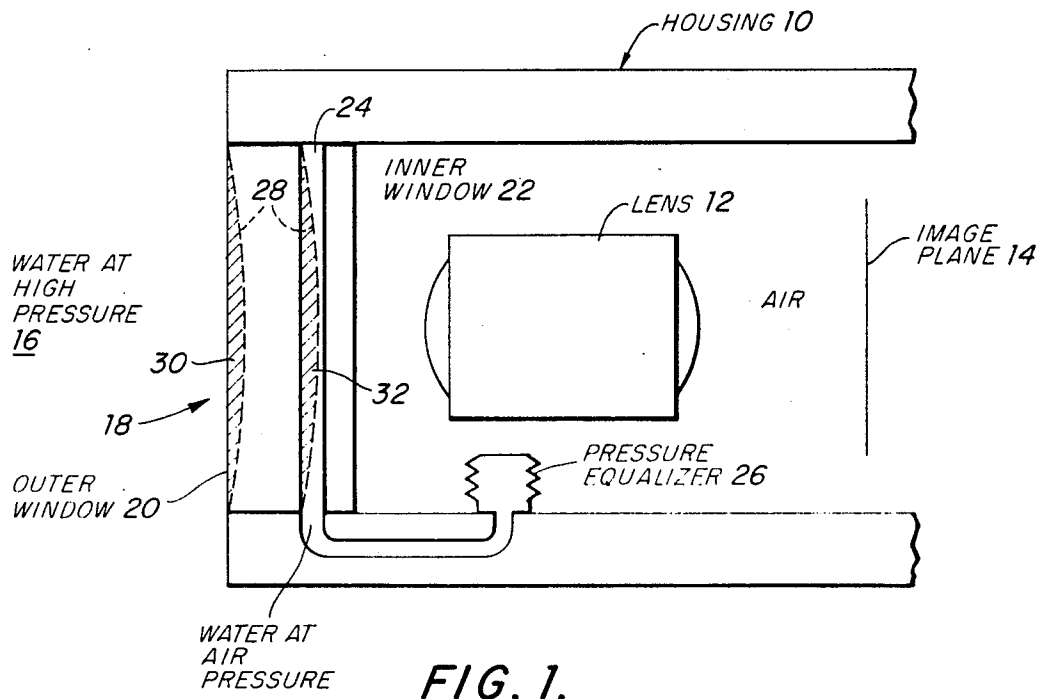
[57] ABSTRACT

A window for separating a protected environment wherein a lens system is located from a high pressure

environment, such as deep sea water, without allowing the high pressure differential across the window to change the optical power of the window and defocus the lens system. The window is constructed in a laminar fashion with a thick outer window, a thin inner window and a compensating section located between said inner and outer window sections. The compensating section is filled with a fluid having the same index of refraction as the fluid of the high pressure environment, and is exposed to the pressure of the protected environment. This arrangement results in the entire pressure differential between the outer environment and the protected environment being placed across the thick outer window section. The fluid in the compensating section accommodates any deformation of the outer window section caused by the high pressure differential. No pressure is exerted across the inner window section which defines the water-air interface between the outer and inner environments. It is this water-air interface which affects the optical power of the window, and accordingly the optical power of the window does not change.

9 Claims, 2 Drawing Figures





MULTIELEMENT WINDOW

BACKGROUND OF THE INVENTION

The present invention relates generally to windows which are placed in front of lens systems, and wherein the window protects the lens system from a high pressure differential existing across the window. More particularly the present invention relates to an improved window with a unique laminar structure whereby a pressure differential across the window does not distort the window in a manner which would change the optical power of the window.

In the field of protective windows for optical systems wherein a large pressure differential exists across the window, it has been the general practice to employ simply a thick plane parallel window or a thick concentric spherical window. the thickness of these windows was designed to be sufficient to withstand the pressure differential across the window. These prior art windows have been unsatisfactory in that deformation of the window caused by the pressure differential ordinarily caused defocus of the lens system. An undistorted plane parallel window has no optical power of its own. However, deformation of the window caused by a large pressure differential causes a change in optical power across the window when the different optical media on the two sides of the window have different indices of refraction.

SUMMARY OF THE INVENTION

In accordance with a preferred embodiment, an improved window with a unique laminar structure is disclosed whereby a pressure differential across the window does not change the optical power of the window. The preferred embodiment provides a window including an outer window section, an inner window section, and a compensating section located between the outer and inner window sections. The compensating section is filled with a fluid exposed to the pressure within the window and having an index of refraction which is approximately equal to the index of refraction of the environment outside the window. Exposing this fluid to the pressure inside the window results in the entire pressure differential across the window being placed across the outer window section. In this manner, the inner window section, which defines the optical power of the window, is not distorted to change the optical power of the window. Further, the preferred embodiment provides such a window for use at great depths under water, and wherein the fluid in the compensating section is also water.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a first embodiment of the invention wherein the window is a plane parallel window.

FIG. 2 shows a second embodiment of the invention wherein the window is a concentric spherical window.

DESCRIPTION OF A PREFERRED EMBODIMENT

FIG. 1 illustrates a plane parallel window built according to the teachings of this invention. A housing 10 contains a lens system 12. The lens system forms an image upon image plane 14 of objects located in an outer environment 16. A window 18 enables the lens system 12 to view objects in environment 16. Window 18 is formed in a laminar structure and has a thick

outer section 20, a thin inner section 22, and a compensating section 24. Compensating section 24 is filled with a fluid which has approximately the same index of refraction as the outer environment 16. The fluid within compensating section 24 is maintained at the pressure within the housing by a pressure equalizer system 26. The embodiment illustrated in FIG. 1 was built to operate at deep sea depths, and the fluid within compensating section 24 is water.

When the housing 10 is not lowered to a great depth in water, the pressure inside housing 10 is approximately the same as the pressure outside the housing 10, and window 18 does not have a pressure differential across it. With no pressure differential across it, the outer window section 20 forms the shape of a plane parallel plate of glass. When the housing 10 is lowered under water, a pressure differential exists across mirror 18 between the water at high pressure in the environment 16 and the air in the housing 10. Since the fluid in compensating section 24 is at the same pressure as the air in air housing 10, all of the pressure differential will be across outer window section 20. This causes outer window section 20 to deform as shown by exaggerated dashed lines 28. A section 30 previously occupied by glass will now be occupied by water. Likewise a section 32 previously occupied by water will now be occupied by glass. Inner window 22, not having a pressure differential across it, will retain its undeformed shape.

The operation of this invention may be explained as follows. If a window is used to separate an object space media from an image space media and the indices of refraction for the two media are different, then the shape of the interface between the two media as defined by the window affects the net optical power across the window. If the interface shape is changed by a bending of the window, then the net optical power across the system will change. However, if the indices of refraction of the two media are the same, then the net optical power across the window is not changed by a bending of the window. This invention utilizes this concept by placing the pressure carrying element between two media having the same index of refraction.

The glass window 18 may be considered as simply a means for separating the existing water-air interface. The difference in indices of refraction between water and air causes a change of optical power in the system if the pressure differential is allowed to distort this water-air interface. This invention effectively operates to prevent a distortion of the water-air interface. If inner window section 22 and compensating section 24 were not provided, then window 20 would have its optical power changed by the deformation of the water-air interface defined by outer window section 20. This change in optical power is prevented by inner window section 22 and compensating section 24, as now the water-air interface is defined by inner window section 22. Glass previously present in section 30 when the outer window section 20 was undeformed is effectively transferred to section 32 in the deformed condition of window section 20. Likewise water previously present in section 32 is now effectively transferred to section 30. This effective transfer of water is the reason the fluid in compensating section 24 should have approximately the same index of refraction as the fluid in environment 16. As seen in FIG. 1, inner window section 22, which now defines the water-air interface, remains

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a plane parallel plate, and thus the window 18 does not change its optical power and defocus lens system 12.

FIG. 2 illustrates a second embodiment of this invention wherein the window is a concentric spherical window. The window has an outer window section 42, and inner section 44, and a compensating section 46. The operation of the embodiment illustrated in FIG. 2 is substantially the same as the operation of the embodiment illustrated in FIG. 1, and accordingly will not be gone into in detail. Although the windows illustrated in FIGS. 1 and 2 were designed to have zero optical power, the teachings of this invention extend to embodiments having negative or positive optical power. For instance, some embodiments might be designed having nonconcentric spherical surfaces, and other embodiments might be designed with aspherical surfaces. Also, in some embodiments the lens system might not be required.

While several embodiments have been described, the teachings of this invention will suggest many other embodiments to those skilled in the art.

I claim:

1. An optical window for separating the interior of a housing from an environment and wherein a pressure differential exists between the pressure in the interior of the housing and the pressure of the environment and without changing the net optical power across the window when the pressure differential is applied across the window, and comprising:

- a. a housing having an aperture therein and adapted to be surrounded by an environment, there being a pressure differential between the pressure in the interior of said housing and the pressure of the environment, said environment having a given index of refraction; and
- b. a window fixedly and immovably mounted in said aperture in said housing for allowing a view of the environment, said window including an outer window section, means for fixedly and immovably

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mounting said outer window section to said housing in said aperture, an inner window section, means for fixedly and immovably mounting said inner window section to said housing in said aperture and a compensating section located between said outer and inner window sections, said compensating section having a fluid located therein and exposed to the pressure within said housing, said fluid having an index of refraction approximately equal to said given index of refraction, whereby only said outer window section will be deformed by the pressure differential across said window, and the interface between the environment and the interior of said housing will not be deformed and result in a change in the net optical power across the window.

2. Apparatus as set forth in claim 1 wherein said window is a plane parallel window.

3. Apparatus as set forth in claim 1 wherein said window is a concentric spherical window.

4. Apparatus as set forth in claim 1 wherein the environment is an environment wherein water at a very high pressure exerts a large pressure differential across said window, and said fluid in said compensating section is water.

5. Apparatus as set forth in claim 1 and including an optical system positioned inside said housing for viewing the environment.

6. Apparatus as set forth in claim 5 wherein said optical system is a lens system.

7. Apparatus as set forth in claim 6 wherein the environment is an environment wherein water at a very high pressure exerts a large pressure differential across said window, and said fluid in said compensating section is water.

8. Apparatus as set forth in claim 7 wherein said window is a plane parallel window.

9. Apparatus as set forth in claim 7 wherein said window is a concentric spherical window.

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