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(54) Title: A FLOOD CONTROL VALVE ASSEMBLY

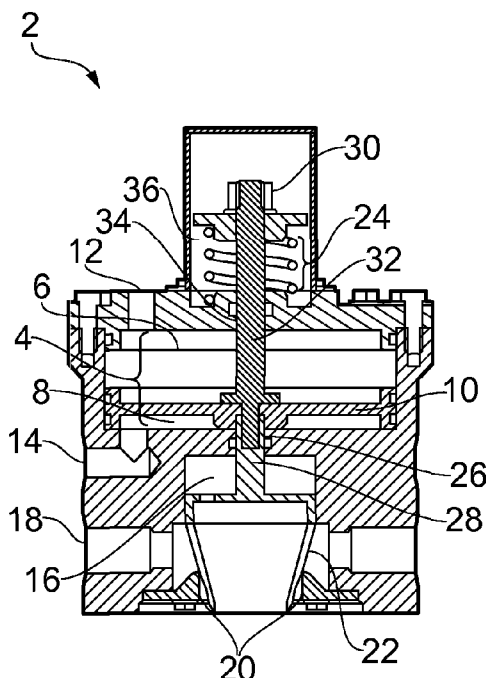


FIG. 1

(57) Abstract: A flood control valve assembly suitable for a submarine has a first chamber (4) with two compartments (6,8) separated by a movable wall (10) and inlets (12,14) communicating respectively with the two compartments (6,8), and a second chamber with a fluid flow duct and a flood control element formed by a valve body (20) and a fluid flow restrictor (22) connected to the movable wall (10), and defining a valve orifice between the valve body (20) and the fluid flow restrictor (22) in communication with the fluid flow duct. The transverse width of the valve orifice, is dependent on the relative position of the valve body (20) and fluid flow restriction (22) and the movable wall is biased to urge the flood control element in which the width of the valve orifice is greater than in other positions of the flood control element.



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A Flood Control Valve AssemblyBackground of the Invention5 Field of the Invention

This invention relates to flood control valve assemblies and marine vessels having flood control valve assemblies. For example, embodiments of this invention
10 may be used as a depth compensating flood control valve assembly for automatically controlling the rate at which a submarine escape chamber is flooded.

Summary of the Prior Art

15

Flood valves are used to control the rate at which fluid flows through the valve into a space to be flooded. Flood valves are used in submarine escape chambers to flood the submarine escape chamber with seawater in order
20 to increase the pressure of the escape chamber towards surrounding seawater pressure.

A submarine escape chamber is a compartment in a submarine which allows crew to escape from a submarine.
25 The pressure in the submarine is usually controlled to approximately 1 bar. The escape chamber has an inboard hatch and an outboard hatch. When a submarine is below the surface of water the external pressure on the outboard hatch is greater than the pressure inside the
30 submarine. The outboard hatch can only be opened to allow for escape from a submarine when pressure in the escape chamber is substantially equal to external water pressure.

In order to maximise the chance of safely escaping from a submarine during an emergency evacuation at depth, it is essential that the escapee is pressurized from internal submarine pressure (approximately 1 bar) to
5 depth pressure at a controlled rate. While it is desirable for escape to be possible as quickly as possible, the pressure increase must occur at a rate that is safe for an escapee to withstand. This controlled rate should be no greater than a doubling of pressure
10 every 4 seconds.

During this pressurisation process the escapee is enclosed within the escape chamber that is gradually flooded to depth pressure by allowing seawater into the
15 chamber. The flow rate of seawater into the chamber is set by the characteristics of a flood valve, primarily the area of its orifice.

Conventionally a flood valve has a fixed orifice
20 area and therefore has a flow optimised for a single specific depth of water.

Summary of the Invention

25 The present inventors have found that in order for the rate of fluid flow through a flood valve to be controlled so that pressurisation of a chamber occurs at a predetermined safe rate, it is necessary for the area of a valve orifice, through which fluid flows from the
30 flood valve into the chamber to be pressurised, to be variable to enable, for example, an optimised fluid flow rate through the flood valve within the depth range of a submarine so that the chamber may be pressurised at an

optimum safe rate at any depth within the submarine's depth range.

At its most general the present invention provides a
5 flood control valve assembly having a variable orifice, a
moveable orifice adjustment component and a biasing
member. The variable orifice is adjustable in dependence
on the orifice adjustment component, the orifice
adjustment component being moveable in response to a
10 pressure difference between two regions under the
influence of the biasing member.

The flood control valve assembly of the present
invention provides the advantage that the rate at which
15 fluid flows through the valve is mechanically and
automatically controlled by varying the area of the valve
orifice in response to the difference in pressure between
regions between which fluid is required to flow, for
example the difference between seawater pressure and
20 internal submarine pressure.

Thus, in a first aspect the present invention may
provide a flood control valve assembly comprising:

a first chamber containing a first compartment and a
25 second compartment, the first and second compartments
being separated by a moveable wall, the moveable wall
being moveable in a first direction, the first chamber
also having a first inlet in fluid communication with the
first compartment, and a second inlet in fluid
30 communication with the second compartment; and

a second chamber having a fluid flow duct and a
flood control element, the flood control element having a
valve body and a fluid flow restrictor extending in the
valve body, the valve body and the fluid flow restrictor

being moveable relative to each other in dependence on the moveable wall between a first position and a second position, the valve body and the fluid flow restrictor being shaped such as to define a valve orifice

5 therebetween, the fluid flow duct being in fluid communication with the valve orifice,

wherein the area of the valve orifice in a plane transverse to the direction of relative movement is variable dependent on the relative position of the valve
10 body and the fluid flow restrictor, the area of the valve orifice being less in the first position than in the second position, and the moveable wall being biased by a biasing member to urge the flood control element towards the second position.

15

The first chamber has two compartments separated by a moveable wall, the first and second inlets allow the first and second compartments to receive fluids at different pressures. When the first compartment contains
20 fluid at a different pressure to fluid contained in the second compartment, the moveable wall will be forced towards the compartment containing fluid at lower pressure by the higher pressure fluid contained in the other compartment.

25

Movement of the moveable wall occurs automatically when there is a difference in pressure between the fluid contained in the first compartment and the fluid contained in the second compartment. The greater the
30 difference in pressure between the fluids contained in the first and second compartments, the greater the force exerted by the moveable wall on the flood control element. The biasing member acts against the force of the higher pressure liquid to ensure that the area of the

valve orifice is varied as the difference in pressure between the fluid contained in the first compartment and the fluid contained in the second compartment is reduced.

5 Preferably the area of the valve orifice is increased as the difference in pressure between the fluid contained in the first compartment and the fluid contained in the second compartment is reduced.

10 The moveable wall and the biasing member together provide mechanical and automatic control of the flood control element, and therefore the area of the valve orifice, as the valve body and the fluid flow restrictor are moved relative to one another in response to the
15 pressure difference across the moveable wall. This control of the area of the valve orifice may be used to control the rate of fluid flow from the fluid flow duct through the flood valve control assembly.

20 This mechanical flood control valve assembly with a variable valve orifice provides the advantage that flooding from a high pressure region to a low pressure region can be automatically controlled to an optimum safe rate whatever the difference in pressure between the high
25 pressure region and the low pressure region without the need for electronic systems. Therefore, the flood control valve assembly of the present invention may be used as a depth compensating flood control valve for controlling the rate at which a submarine escape tower is
30 flooded with seawater. The flood control valve assembly allows seawater to flow through the flood control valve so that a submarine escape tower is automatically pressurised at the optimum safe rate at any depth within

the submarine's depth range. The optimum safe rate is known to be a doubling of pressure every 4 seconds.

5 The present inventors have found that the variable area of the valve orifice may be used to control the rate of fluid flow through a flood control valve assembly to a predetermined rate taking into account the difference in pressure across the moveable wall.

10 The variable area of the valve orifice is determined by the relative configurations of the valve body and fluid flow restrictor. Whilst it is possible for each to have a variable profile in the direction of relative movement, it will normally be easier for one or the other
15 to have a shaped profile which is the primary determinant of the variable area. Thus, it is preferable that the fluid flow restrictor has profile which enables the area of the valve orifice to be varied as the valve body and the fluid flow restrictor move relatively to
20 each other, but alternatives are possible in which it is the valve body which has the appropriate profile. Of course, whether or not it is the fluid flow restrictor or the valve body which has the shaped profile in the direction of relative movement, the other of the fluid
25 flow restrictor and valve body will need to have a suitable shape to provide a suitable variation of the area of the orifice as the relative movement occurs.

The configuration of the area of the valve orifice
30 depends on the shape of the fluid flow restrictor and the valve body, along with their positions relative to each other in both the direction of relative movement and in a plane transverse to the direction of relative movement.

Suitably the valve body and the fluid flow restrictor are positioned and/or shaped to form a valve orifice having a continuous path in a plane transverse to the direction of relative movement, such that the area of the valve orifice surrounds the fluid flow restrictor.

Preferably the fluid flow restrictor and the valve body are coaxially aligned in a plane transverse to the direction of relative movement. When the fluid flow restrictor and the valve body are coaxially aligned in said plane and shaped to have a circular cross-section in a plane transverse to the direction of relative movement, the area of the valve orifice takes the form of an annulus.

Preferably the biasing member is preloaded such that the force exerted by the biasing member on the moveable wall causes the area of the valve orifice to increase as the pressure difference across the moveable wall is decreased. More preferably the area of the valve orifice is maximised when there is no pressure difference across the moveable wall. Optionally the biasing member is a spring. Preferably the biasing member is preloaded in compression.

In one embodiment the biasing member is located in a third chamber, the biasing member being connected to the moveable wall through an aperture in the first chamber by a second connecting element. Optionally the third chamber is sealed from the first chamber to prevent fluid from the first chamber entering the third chamber, for example, to prevent corrosion of the biasing member due to contact with fluids contained in the first chamber.

In embodiments the flood control valve assembly has a biasing member adjustment means for adjusting the force exerted by the biasing member on the moveable wall. This allows the biasing member to be adjusted to exert a
5 predetermined force on the moveable wall. Preferably the biasing member is adjusted using the biasing member adjustment means such that when the pressure of fluid in the first compartment is equal to pressure of fluid in the second compartment the force exerted by the biasing
10 member on the moveable wall causes the valve orifice to be fully opened. In embodiments, the biasing member adjustment means comprises a nut and a complimentary screw thread.

15 In embodiments the moveable wall is connected to the flood control element through an aperture in the first chamber by a first connecting element. In an embodiment the moveable wall is connected to the fluid flow restrictor of the flood control element. The first
20 connecting member causes movement of the fluid flow restrictor relative to the valve body when there is a difference in the pressure of fluid contained in the first and second compartments. In an alternative embodiment the moveable wall is connected to the valve
25 body. In this case the first connecting member causes the movement of the valve body relative to the fluid flow restrictor when there is a difference in the pressure of fluid contained in the first and second compartments. Preferably the direction of relative movement is
30 substantially parallel to the first direction.

Suitably the first chamber is sealed from the second chamber to prevent fluid communication between the two

chambers. Although optionally the fluid flow duct is in fluid communication with the first chamber.

Preferably the flood control valve assembly
5 comprises a releasable locking mechanism for preventing fluid flow between the fluid flow duct and the valve orifice.

In embodiments the releasable locking mechanism has
10 a fluid flow duct inlet valve in fluid communication with the fluid flow duct. The fluid flow duct inlet valve is moveable between a first closed position and a second open position, configured such that in the first closed position the fluid the fluid flow duct inlet valve
15 prevents fluid flow to the fluid flow duct. In the second open position the fluid flow duct inlet valve allows fluid to flow to the fluid flow duct.

The releasable locking mechanism allows fluid flow
20 through the flood control valve assembly to be prevented.

The present inventors have found that the area of the valve orifice in response to pressure difference across the moveable wall may cause the fluid flow through the valve orifice to change from laminar flow to
25 turbulent flow or vice versa. Fluid flow through the valve orifice has been found to be dependent on orifice area and loss co-efficient , the value of the loss co-efficient can be significantly different between laminar and turbulent flow and with the degree of turbulence.
30 Preferably the valve orifice is shaped to take said change in fluid flow into account. The present inventors have found that the area of the valve orifice may be controlled by shaping the valve body and/or the

fluid flow restrictor to provide a non-linear change in the area of valve orifice as the valve body and the fluid flow restrictor are moved relative to each other. The present inventors have found that alternatively or
5 additionally the provision of a non-linear biasing member may be used to provide a non-linear change in the area of the valve orifice as the pressure difference across the moveable wall changes, for example, the pressure difference between the internal pressure of a submarine
10 and the pressure of seawater at a particular submarine depth.

In embodiments the fluid flow restrictor has a non-linear profile to allow for the valve orifice to be
15 varied non-linearly as the valve body and fluid flow restrictor are moved relative to each other in response to a pressure difference across the moveable wall. Preferably the fluid flow restrictor has a concave profile. However, there may be circumstances where a
20 fluid flow restrictor with a convex profile is suitable to achieve a desired fluid flow rate through the flood control valve assembly. There may be arrangements in which a discontinuous non-linear profile of the fluid flow restrictor is preferred to provide a flood control
25 valve assembly having desirable fluid flow characteristics.

It is currently understood that fluid flow restrictor having a non-linear profile results in a flood
30 control valve assembly having suitable fluid flow characteristics.

In embodiments the valve body has a non-linear profile to allow for the valve orifice to be varied non-

linearly as the valve body and fluid flow restrictor are moved relative to each other in response to a pressure difference across the moveable wall. Optionally the valve body has a convex profile. Alternatively the valve
5 body has a concave profile. Suitably the valve body has a discontinuous non-linear profile.

In embodiments both the fluid flow restrictor and the valve body may be shaped as described above to allow
10 for the valve orifice to be varied non-linearly as the fluid flow restrictor and the valve body are moved relative to each other.

The present inventors have found that the fluid flow
15 restrictor and/or the valve body having a non-linear profile provides the advantage that the area of the valve orifice is variable non-linearly as the pressure difference across the moveable wall is changed. This non-linear variation in the area of the valve orifice in
20 response to a linear change in the pressure difference across the moveable wall allows improved control of the rate of fluid flow through a flood control valve. This improved control over fluid flow rate allows the flood control valve assembly to be used to control fluid flow
25 into a chamber, to increase pressure within the chamber at an optimum safe rate taking into account the difference in pressure across the moveable wall.

In another embodiment the biasing member is a non-
30 linear biasing member. The present inventors have found that the provision of a non-linear biasing member allows the area of the valve orifice to be varied non-linearly even if both the valve body and fluid flow restrictor have a linear profile. The non-linear biasing member is

configured to cause non-uniform relative movement between the valve body and the fluid flow restrictor such that the area of the valve orifice is varied non-uniformly as the difference in pressure across the moveable wall varies, for example as the pressure difference decreases. The non-linear biasing member may be used in combination with a linear or non-linear valve body and a linear or non-linear fluid flow restrictor. In embodiments the non-linear biasing member comprises a non-linear spring.

The provision of a non-linear biasing member provides the same advantages as those discussed above for a non-linear fluid flow restrictor or a non-linear valve body.

In a second aspect the present invention may provide a marine vessel having the flood control valve assembly as discussed above with reference to the first aspect.

In one embodiment the first inlet is in fluid communication with the exterior of the marine vessel and the second inlet is in fluid communication with the interior of the marine vessel. Preferably the fluid flow duct is in fluid communication with the exterior of the marine vessel.

In one embodiment the marine vessel is a submarine having an escape chamber, the interior of the escape chamber being in fluid communication with the valve orifice of a flood control valve assembly. The flood control valve assembly may be used to automatically control the rate at which a submarine escape chamber is flooded to allow pressurisation of the submarine escape chamber at the optimum safe rate. The variable area of

the valve orifice allows for automatic pressurisation of the submarine escape chamber at a safe rate at any depth within the submarine's depth range.

5 A submarine has an outer casing and an internal pressure hull. The submarine pressure hull normally maintains the pressure of the interior of the submarine at approximately 1 bar. An escape chamber is provided in a submarine to form a channel linking the interior of the
10 submarine through the pressure hull with the exterior of the submarine. The escape chamber is sealable from the interior of the submarine at its entrance and sealable from the exterior of the submarine at its exit.

15 Preferably the first inlet and the fluid flow duct are in fluid communication with the exterior of the submarine and the second inlet is in fluid communication with the interior of the submarine.

20 The advantages associated with the first aspect also apply to this second aspect.

Brief Description of the Drawings

25 The present invention will now be described by way of example only with reference to the accompanying drawings in which:

30 Figure 1 is a schematic cross-section of a flood control valve assembly being an embodiment of the present invention, the flood control element shown in the first position;

Figure 2 is a schematic cross-section of the flood control valve assembly of figure 1, the flood control element shown in between the first position and the second position;

5

Figure 3 is a schematic cross-section of the flood control valve assembly of figure 1, the flood control element shown in the second position;

10

Figure 4 is a graph showing an example of the variation of the valve orifice area with water depth to achieve a predetermined fluid flow rate through the flood control valve assembly in order to pressurise a particular submarine escape chamber at a predetermined

15

rate; and

Figure 5 is a schematic cross-section of a submarine escape chamber being an embodiment of the present invention.

20

Detailed Description

Figure 1 shows a flood control valve assembly of the present invention. The flood control valve assembly has a main body 2 housing three chambers separated from one another by integral walls, which define a first chamber 4 and a second chamber 16.

The first chamber 4 is divided into two compartments; a first compartment 6 and a second compartment 8 separated by a moveable wall 10. The first chamber 4 has a first inlet 12 to allow fluid to enter the first compartment 6 from outside the main body 2, and a second inlet 14 to allow fluid to enter the second

compartment 8 from outside the main body 2. When the fluid contained in the first compartment 6 is at a different pressure to the fluid contained in the second compartment 8, the moveable wall 10 is moved towards the compartment containing the lower pressure fluid.

The second chamber 16 contains a flood control element having a valve body 20 and a fluid flow restrictor 22. The fluid flow restrictor 22 is connected to the moveable wall 10 of the first chamber 4 by a first connecting element 28 through an aperture 26 in the first chamber 4. A pressure difference between the fluids contained in the first compartment 6 and the second compartment 8 of the first chamber 4 causes the moveable wall 10 to move towards the compartment containing the lower pressure fluid, which in turn moves the fluid flow restrictor 22 relative to the valve body 20 to change the area of a valve orifice 38 (not shown in figure 1) formed between the fluid flow restrictor 22 and the valve body 20. A fluid flow duct 18 provides a fluid path from the exterior of the main body 2 to the flood control element. Fluid entering the flood control valve assembly through the fluid flow duct 18 may exit the flood control valve assembly through the valve orifice 38 when the fluid flow restrictor 22 and the valve body 20 are positioned relative to each other so that the valve orifice 38 is formed between them.

The third chamber 36 houses a spring 24 as the biasing member. The spring 24 is connected to the moveable wall 10 by a second connecting member 32 through an aperture 34 in the first chamber 4. The spring 24 acts on the moveable wall 10 in the opposite direction to the force exerted by the higher pressure fluid contained

in the first chamber 4. Therefore, if the higher pressure fluid acts on the moveable wall 10 to force the fluid flow restrictor 22 into the valve body 20 to minimise the area of the valve orifice 38, the spring 24
5 acts on the moveable wall 10 to increase the area of the valve orifice 38.

In the embodiment shown in figure 1, the first inlet 12 should be supplied with fluid at a higher pressure
10 than that of the fluid supplied to the second inlet 14. For example, the first inlet 12 may be in fluid communication with seawater surrounding a submarine and the second inlet 14 in fluid communication with the interior of the submarine. Therefore, once the first
15 compartment 6 contains fluid at a higher pressure than the pressure of fluid contained in the second compartment 8 the moveable wall 10 will move towards the second compartment 8. The spring 24 housed in the third chamber 36 is connected to the moveable wall 10 by the second
20 connecting element 32 through the aperture 34 in the first chamber 4 to urge the moveable wall 10 towards the first compartment 6. In this embodiment the spring 24 is preloaded in compression to cause the flood control element to move towards the second position (shown in
25 figure 3) when the pressure of fluid contained in the first compartment 6 is equal to the pressure of fluid contained in the second compartment 8. The fluid flow duct 18 may be in fluid communication with the exterior of a submarine, to supply fluid, e.g. seawater, to the
30 second chamber 16 and the flood control element containing the valve body 20 and the fluid flow restrictor 22.

When the moveable wall 10 moves towards the second compartment 8 the flood control element is moved towards the first position shown in figure 1. The fluid flow restrictor 22 has a non-linear profile to allow the area of the valve orifice 38 to be varied non-linearly in response to the pressure difference across the moveable wall 10, for example the difference in pressure between seawater pressure at a particular depth and internal submarine pressure.

Figure 1 shows the flood control valve assembly in the first position in which fluid flow from the fluid flow duct 18 through the flood control element is restricted due to the small area of the valve orifice 38 (shown in figures 2 and 3).

Figures 2 and 3 show that movement of the moveable wall 10 towards the second compartment 8 in the first direction causes relative movement between the fluid flow restrictor 22 relative to the valve body 20 to increase the area of the valve orifice 38. The area of the valve orifice 38 is increased non-linearly as the spring 24 acts on the moveable wall 10 to increase the area of the valve orifice 38 as the difference in the pressure of the fluids contained in the first and second compartments is reduced. In this embodiment the fluid flow restrictor 22 and the valve body 20 are coaxially aligned in a plane transverse to the direction of relative movement, they are both shaped to have a circular cross-section in a plane transverse to the direction of relative movement. Therefore the area of the valve orifice 38 takes the form of an annulus, with the area of the valve orifice 38 surrounding the fluid flow restrictor 22.

The force provided by the biasing member 24 on the moveable wall 10 may be adjusted using the biasing member adjustment means 30. The biasing member adjustment means 30 may be configured to preload the biasing member 24 in
5 compression or in tension. In this embodiment the biasing member 24 is a spring which is preloaded in compression. The biasing member adjustment means 30 is a nut on a complimentary screw thread. The biasing member adjustment means 30 allows the force provided by the
10 biasing member 24 on the moveable wall 10 to be adjusted so that, for example, the area of the valve orifice 38 is maximised when the pressure of fluid contained in the first compartment 6 is equal to the pressure of fluid contained in the second compartment 8.

15

The rate of fluid flow through the flood control element is determined by the area of the valve orifice 38. The balance between the pressure of fluid contained in the first compartment 6 and the pressure of fluid
20 contained in the second compartment 8 along with the force provided by the biasing member 24 controls the movement of the moveable wall 10. As the first connecting element 28 connects the moveable wall 10 to the fluid flow restrictor 22, the pressure difference
25 across the moveable wall 10 also controls the movement of the fluid flow restrictor 22 relative to the valve body 20. The shape of the fluid flow restrictor 22 and its position relative to the valve body 20 determines the area of the valve orifice 38 and therefore the rate at
30 which fluid may flow through the flood control valve assembly at a particular external pressure.

Figure 4 is a graph showing an example of the variation the area of a valve orifice to achieve a

desired fluid flow rate through a flood control valve assembly at a range of depths, and therefore at a range of external pressures.

5 The area of the valve orifice required across the range of depths, for example the depth range of a submarine, to allow fluid to flow through the flood control valve assembly at a predetermined rate at any depth within the range, may be converted into the profile
10 of a fluid flow restrictor. In other embodiments this information may be used to obtain the profile of the valve body.

 The exact profile of the fluid flow restrictor
15 and/or valve body may depend on the particular size and geometry of the submarine escape chamber and the associated pipework, to achieve a fluid flow rate through the flood control valve assembly to allow pressurisation of the escape chamber to be maintained at a predetermined
20 rate.

 Figure 5 shows a submarine escape chamber 70 comprising a flood control valve assembly 52 according to the first aspect of the invention, as illustrated in
25 figures 1 to 3. The flood control valve assembly shown in figures 1 to 3 is installed in the submarine escape chamber with the first inlet 12 and the fluid flow duct 18 in fluid communication with the exterior of the submarine so that seawater at external pressure may enter
30 the first compartment 6 and the second chamber 16 of the flood control valve assembly, and the second inlet 14 in fluid communication with the interior of the submarine to allow air at internal submarine pressure, usually

maintained at approximately 1 bar, into the second compartment 8.

To escape from a submarine an escapee enters the
5 submarine escape chamber through an inboard hatch 60 from
a main body of the submarine housed inside the submarine
pressure hull 64. If the pressure outside of the
submarine is equal to the pressure inside the submarine
pressure hull 64, an outboard hatch 58 may be opened
10 using an outboard hatch operating handle 66. However,
when the pressure outside the submarine external casing
62 is greater than the pressure inside the escape chamber
it will not be possible to open the escape hatch 58 due
to the external pressure, for example seawater pressure,
15 forcing the escape hatch 58 closed.

As the internal submarine pressure inside the
submarine pressure hull 64 is normally controlled to 1
bar, when an escapee enters the escape hatch the chamber
20 pressure will be approximately 1 bar, this is much lower
than external seawater pressure when the outboard hatch
is below the water surface. Therefore when the external
pressure, for example seawater pressure, is greater than
the chamber pressure the chamber pressure must be raised
25 before the outboard hatch may be opened. To increase
chamber pressure a flood valve handle 54 or 56 is used to
unlock the flood control valve assembly 52 by opening the
fluid flow duct inlet valve (not shown) to allow seawater
to flow through the fluid flow duct inlet valve into the
30 fluid flow duct 18 and through the valve orifice 38 into
the escape chamber. The inboard hatch 60 may be closed
to prevent fluid flowing through the inboard hatch into
the main body of the submarine, inside the submarine
pressure hull 64, from the escape chamber. When the

flood control valve assembly is unlocked, fluid, for example seawater, flows from the fluid flow duct 18, through the flood control element and through the valve orifice 38 into the escape chamber 70. As fluid, for
5 example seawater, enters the chamber the pressure of air in the chamber increases. The area of the valve orifice 38 is controlled by the position of the fluid flow restrictor 22 relative to the valve body 20. The
10 relative movement of the valve body 20 and the fluid flow restrictor 22 is caused by the moveable wall 10 connected to the fluid flow restrictor 22 by the first connecting member 28 through the aperture 26 in the first chamber 4, and the biasing member 24.

15 In this embodiment, the first inlet 12 allows seawater at external pressure to flow into the first compartment 6, and the second inlet 14 allows fluid at internal submarine pressure, for example air within the submarine pressure hull 64, to enter the second
20 compartment 8. The balance between external pressure of fluid in the first compartment 6, internal submarine pressure of fluid in the second compartment 8, and the force provided by the biasing member 24, controls the movement of the moveable wall 10. As the moveable wall
25 10 is connected to the fluid flow restrictor 22 this automatically controls the area of the valve orifice 38 to ensure that fluid, for example seawater, flows through the fluid flow duct 18 and through the flood control element into the escape chamber at a rate that causes
30 chamber pressure to increase at the optimum safe rate of no greater than a doubling of pressure every 4 seconds at any depth within the submarine's depth range.

When the pressure inside the escape chamber is equal to the external pressure of seawater the outboard hatch 58 may be opened for escape. Once the outboard hatch 58 is closed, the escape chamber maybe drained using a drain
5 valve 68.

The skilled person understands that modifications may be made to the flood control valve assembly of the present invention within the scope of the claims as
10 interpreted by the description and the drawings.

Claims:

1. A flood control valve assembly comprising:
- 5 a first chamber containing a first compartment and a second compartment, the first and second compartments being separated by a moveable wall, the moveable wall being moveable in a first direction, the first chamber also having a first inlet in fluid communication with the first compartment, and a
- 10 second inlet in fluid communication with the second compartment; and
- a second chamber having a fluid flow duct and a flood control element, the flood control element
- 15 having a valve body and a fluid flow restrictor, the valve body and the fluid flow restrictor being moveable relative to each other in dependence on the moveable wall between a first position and a second position, the valve body and the fluid flow
- 20 restrictor being shaped such as to define a valve orifice therebetween, the fluid flow duct being in fluid communication with the valve orifice,
- wherein the area of the valve orifice in a plane transverse to the direction of relative
- 25 movement is variable dependent on the relative position of the valve body and the fluid flow restrictor, the area of the valve orifice being less in the first position than in the second position, and the moveable wall being biased by a biasing
- 30 member to urge the flood control element towards the second position.

2. A flood control valve assembly according to claim 1, wherein the fluid flow restrictor has a non-linear profile.
- 5 3. A flood control valve assembly according to claim 2, wherein the fluid flow restrictor a convex profile.
- 10 4. A flood control valve assembly according to claim 2 or claim 3, wherein the fluid flow restrictor has a discontinuous profile.
- 15 5. A flood control valve assembly according to any one of claims 1 to 4, wherein the moveable wall is connected to the flood control element through an aperture in the first chamber by a first connecting element.
- 20 6. A flood control valve assembly according to claim 5, wherein the moveable wall is connected to the fluid flow restrictor.
- 25 7. A flood control valve assembly according to any one of claims 1 to 5, wherein the biasing member is located in a third chamber, the biasing member being connected to the moveable wall through an aperture in the first chamber by a second connecting element.
- 30 8. A flood control valve assembly according to any one of the preceding claims comprising a biasing member adjustment means for adjusting the force exerted by the biasing member on the moveable wall.

9. A flood control valve assembly according to any one of the preceding claims comprising a releasable locking mechanism for preventing fluid flow between the fluid flow duct and the valve orifice.

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10. A marine vessel having a flood control valve assembly according to any one of the preceding claims.

10 11. A marine vessel according to claim 10, wherein the first inlet is in fluid communication with the exterior of the vessel and the second inlet is in fluid communication with the interior of the vessel.

15 12. A marine vessel according to claim 10 or claim 11, wherein the fluid flow duct is in fluid communication with the exterior of the vessel.

20 13. A submarine having an escape chamber, the interior of the escape chamber being in fluid communication with the valve orifice of a flood control valve assembly according to any one of claims 1 to 9.

25 14. A submarine according to claim 13, wherein the first inlet and the fluid flow duct are in fluid communication with the exterior of the submarine and the second inlet is in fluid communication with the interior of the submarine.

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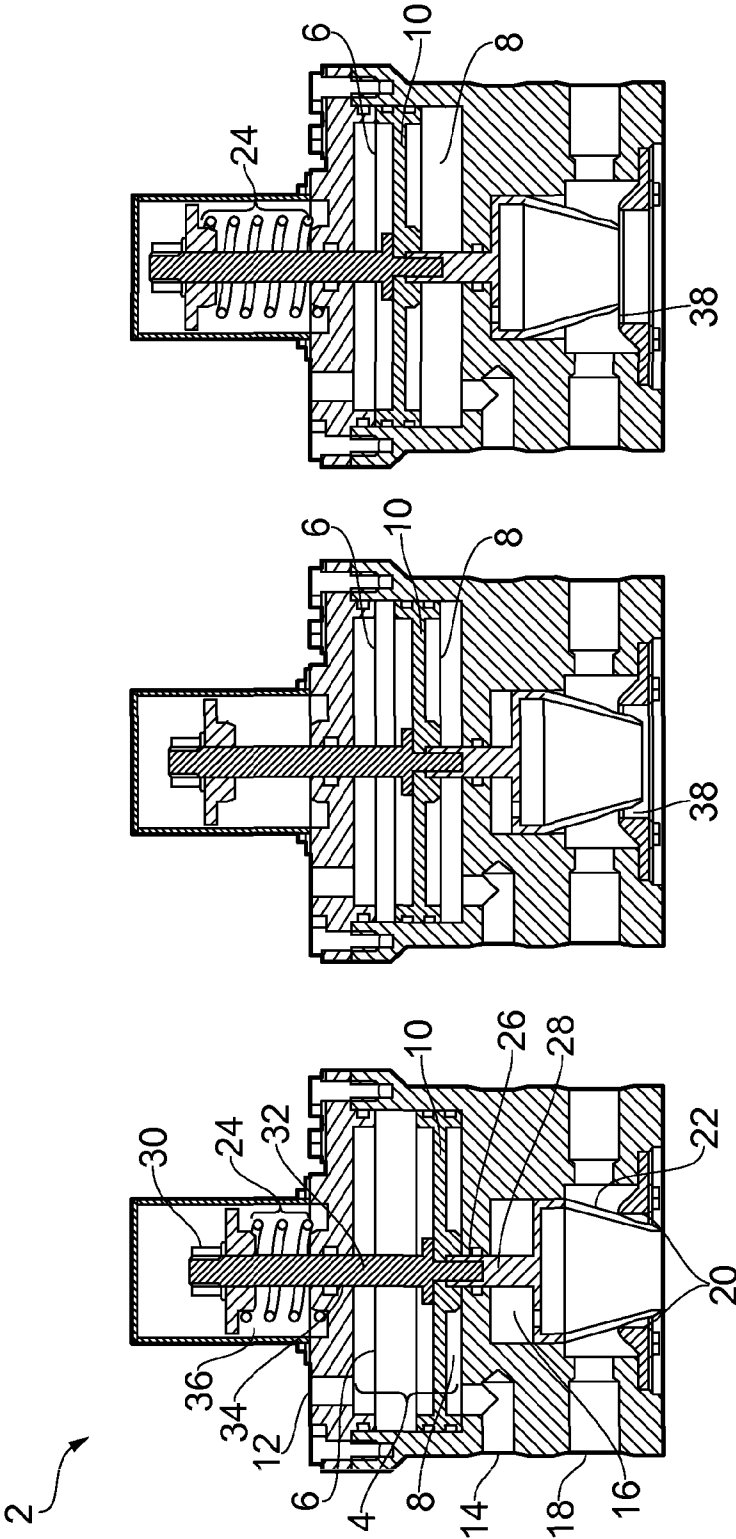


FIG. 3

FIG. 2

FIG. 1

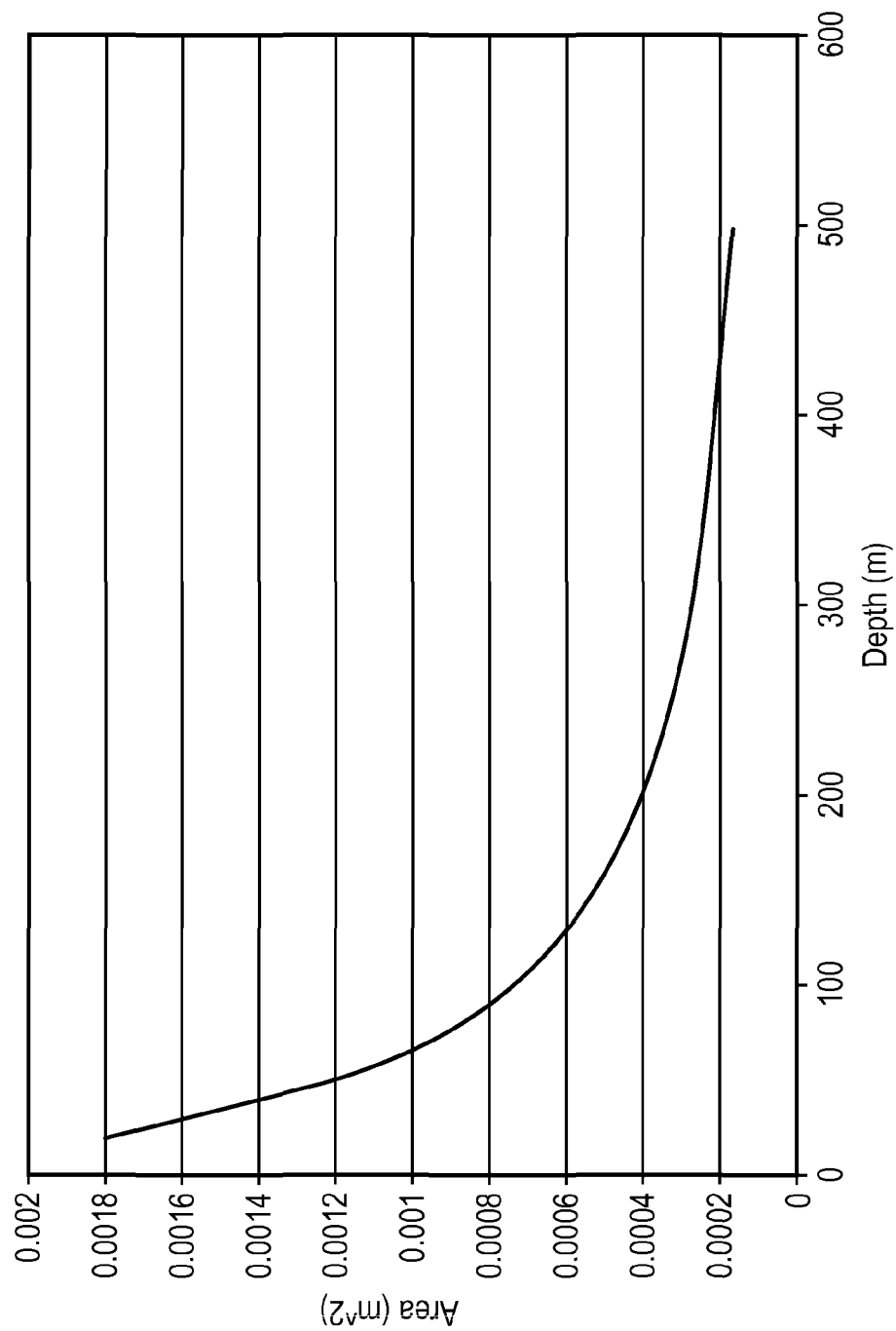


FIG. 4

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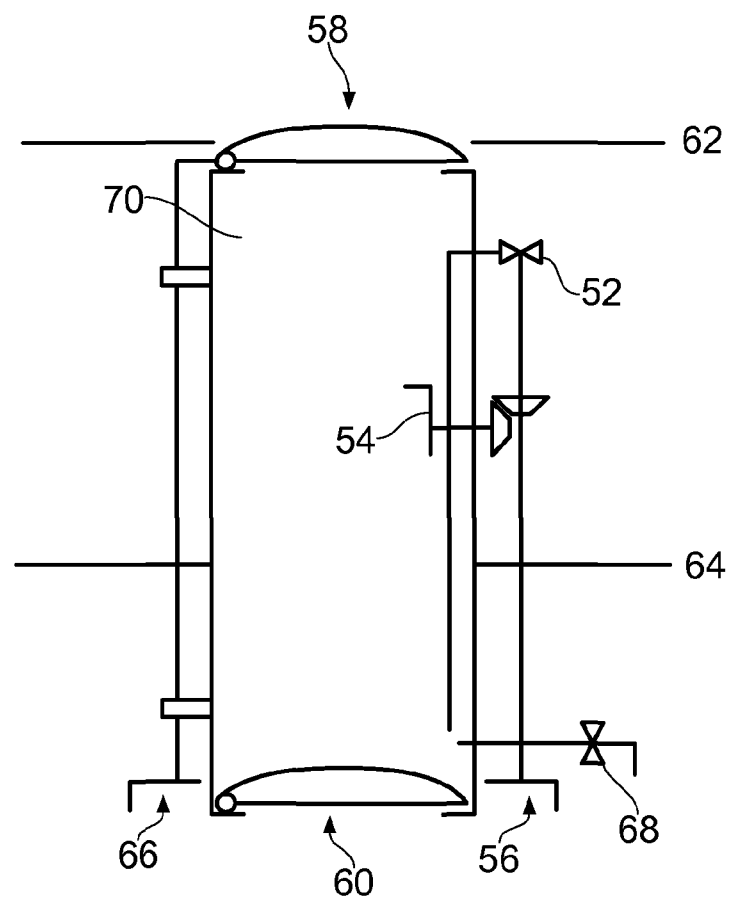


FIG. 5

INTERNATIONAL SEARCH REPORT

International application No

PCT/GB2013/050063

A. CLASSIFICATION OF SUBJECT MATTER INV. F16K31/122 B63G8/41 F16K1/52 F16K1/54 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) B63G F16K		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EP0-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 552 330 A (GROTLOH KARL H [CH]) 12 November 1985 (1985-11-12) figures 3a-3d -----	1,5,6, 10,12
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- / - -		
☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search 5 April 2013	Date of mailing of the international search report 15/04/2013	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Lanel, François	

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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