Dec. 29, 1959 W. A. GAIL 2,918,890

SUBMARINE BALLAST DOOR MECHANISM

Filed March 20, 1958 2 Sheets-Sheet 1

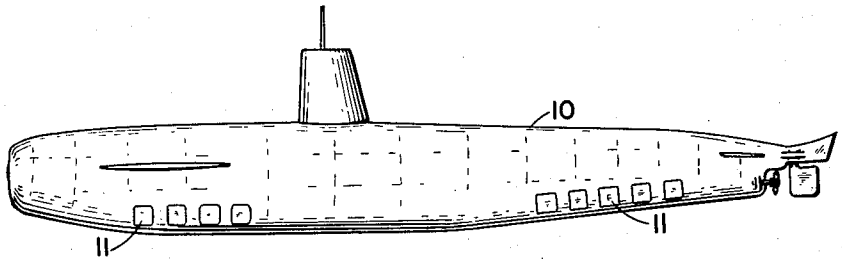


FIG. 1

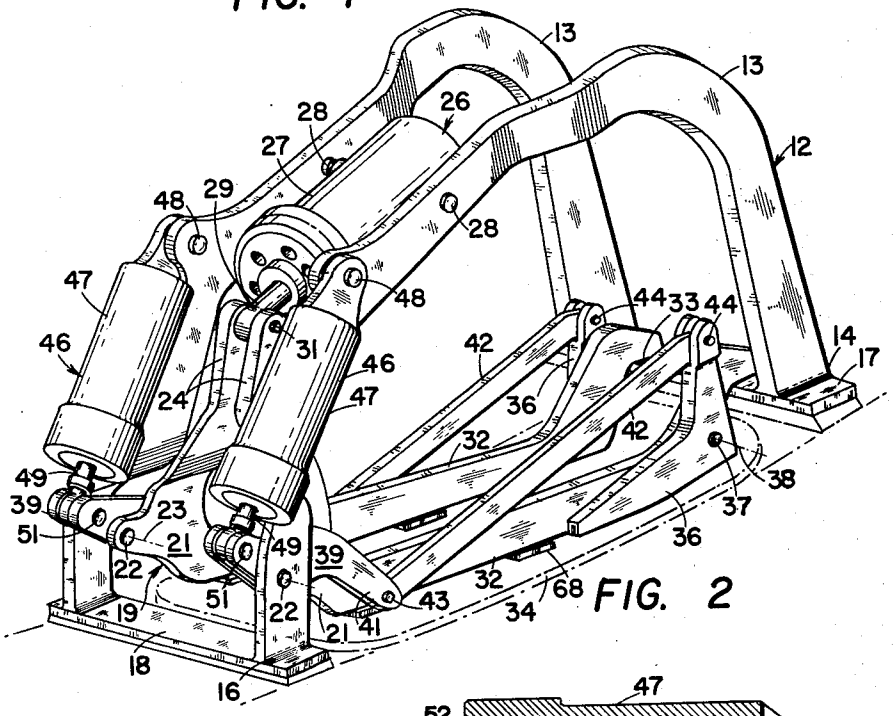


FIG. 2

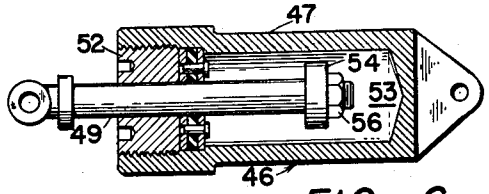


FIG. 6

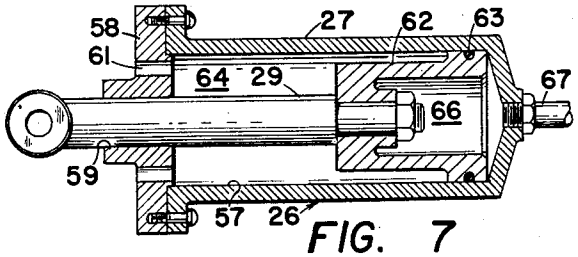


FIG. 7

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SUBMARINE BALLAST DOOR MECHANISM

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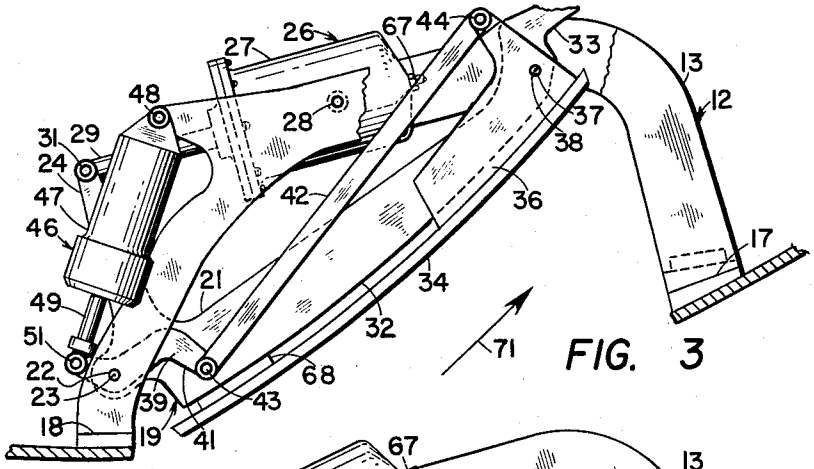


FIG. 3

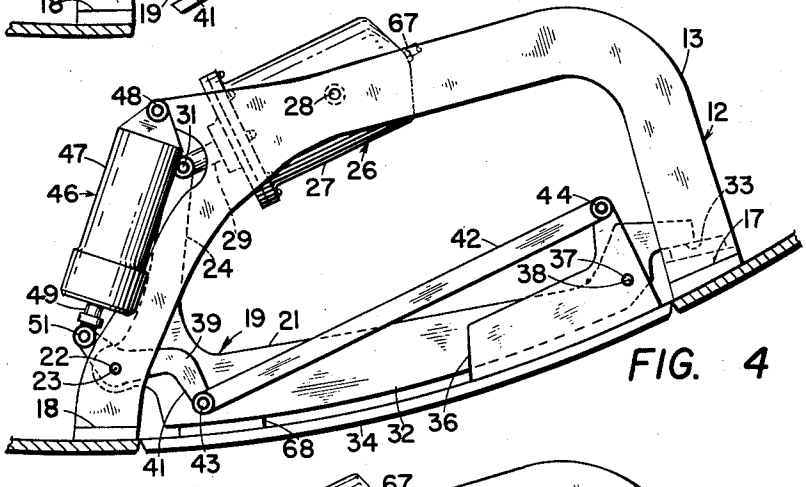


FIG. 4

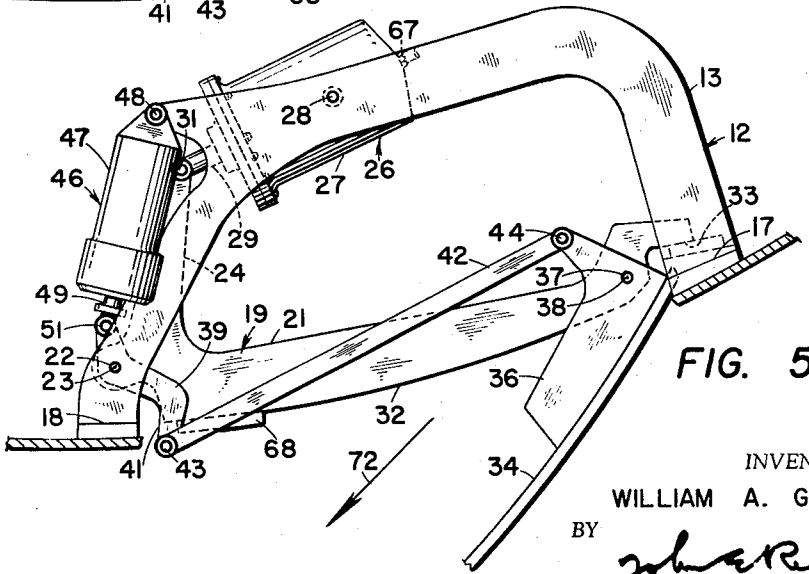


FIG. 5

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SUBMARINE BALLAST DOOR MECHANISM

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Application March 20, 1958, Serial No. 722,762

9 Claims. (Cl. 114—16)

This invention relates generally to door operators and more particularly to a submarine ballast door operating mechanism.

It is customary to provide a plurality of ballast doors which are located along the bottom of the submarine ballast tanks to permit entry and discharge of water from the tanks when the submarine is either submerging or surfacing. Generally speaking, it is desirable to arrange the ballast doors so they are in the open position when the submarine is on the surface and are closed as the submarine dives to an operating depth. The doors remain closed during the submerged operation of the submarine but are open when the tanks are blown for surfacing. It should be understood that even when the doors are closed to improve the streamlining of the submarine hull, a fluid seal is not provided and low rates of leakage, either into or out of the ballast tanks, is permitted for minor adjustment in the trim of the ship.

It is an important object of this invention to provide a new and improved ballast door operator for submarines.

It is another important object of this invention to provide a compound door structure wherein a single spring force is utilized to bias all elements of the compound door.

It is still another important object of this invention to provide a linkage system for operating a compound ballast door for submarines or the like in which a single spring force is capable of operating all of the elements of the door structure.

It is still another object of this invention to provide a ballast door operator including a door frame movable between an open and closed position biased to an open position by a spring in combination with a door carried by the frame movable between closed and open positions biased toward the closed position by the same spring.

It is still another object of this invention to provide a ballast door for submarines and the like wherein a single spring operates a compound door structure in combination with a pressure operated actuator operable to overcome the spring and moving the door to the closed position when submarine reached predetermined operating depths.

Further objects and advantages will appear from the following description and drawings, wherein:

Figure 1 is a schematic side elevation of a submarine on which a ballast door, according to this invention, is installed;

Figure 2 is a perspective view of the ballast door structure incorporating this invention;

Figure 3 is a side elevation of the door structure showing the position the elements assume when the submarine is on the surface;

Figure 4 is a view similar to Figure 3, showing the position of the elements assumed when the door is closed by the pressure of the water at normal operating depths;

Figure 5 is a view similar to Figures 3 and 4 showing the positions of the elements assumed when the ballast tanks are blown to surface the submarine;

Figure 6 is a side elevation in longitudinal section of the preferred liquid spring; and,

Figure 7 is a side elevation in longitudinal section of the pressure sensitive actuator for closing doors when the submarine has reached operating depths.

Referring to the drawings, Figure 1 schematically discloses a submarine **10** to show the environment of the ballast doors **11** according to this invention. Normally, on a submarine, there are forward ballast tanks located in forward of the center gravity of the ship and additional tanks located rearwardly therefrom. The ballast doors are located along the bottom of the ballast tanks and are arranged to open to permit water to enter the bottom of the ballast tanks when air is removed from the top so that the buoyancy of the submarine is reduced and it will dive. When it is desired to surface the submarine, air is blown into the upper portions of the ballast tanks causing the water to flow out of the bottom of the tanks, increasing the buoyancy of the submarine so that the submarine will surface. In practice, the ballast doors are self-contained units controlled or operated by the condition of the ballast tanks and do not require any operation from the submarine itself.

Referring to Figure 2, the ballast door unit includes a base **12**, which is mounted on the submarine. The base is formed with two similar and opposite U-shaped struts **13** which are connected at their ends **14** and **16**, to cross bars **17** and **18** respectively, which are in turn mounted on the submarine **10**. A ballast door frame **19** is formed of similar and opposite members **21**, one of which is pivoted on each of the struts **13** by a pivot pin **22** for rotation around a pivot axis **23**. Each of the frame members **21** is formed wtih a projection **24** which extends upwardly between the struts **13** and is connected to a pressure operated actuator **26**, normally referred to as a sea water actuator. Actuator **26** includes a cylinder **27** pivoted on the struts **13** by trunnions **28** and a plunger **29** pivotally connected to the projections **24** by a pivot pin **31** so that axial movement of the plunger **29** producing rotating of the members **21** around the pivot axis **23**. The members **21** also are provided with lateral extensions **32** terminating in a stop surface **33** engageable wtih the cross bar **17** when the frame members **21** are in their closed position.

A door **34** is provided with hinge members **36**, one of which is pivotally connected to each of the projections **32** of the frame members **21** by a pivot pin **37**, so that the door **34** is carried by the ballast door frame and is rotatable relative thereto around the axis **38** of the pivot pins **37**. Mounted on each of the pivot pins **22** is a rocker arm **39** which is rotatable around the pivot axis **23**. Each of the arms is provided with a leg **41** which is pivotally connected to one end of the tie bar **42** by a pivot pin **43**. The other ends of the tie bars **42** are connected to the associated hinge member **36** by pivot pins **44** so that rotation of the rocker arms **39** around the axis **23** produces rotation of the door **34** around the axis **38**. A pair of liquid springs **46** are provided to resiliently bias the rocker arms **39** in a counterclockwise direction around the pivot axis **23**. Each of the liquid springs includes a cylinder **47** pivoted on the associated strut **13** by a pivot pin **48** and a plunger **49** pivotally connected to the associated rocker arm **39** by a pin connection **51**.

Each of the liquid springs **46** is a similar structure so only one is shown in detail in Figure 6. The plunger **49** projects through and is axially movable relative to a gland **52** mounted on the cylinder **47**. The cylinder **47**, gland **52**, and plunger **49** co-operating to define a cavity **53** filled with liquid which is compressed when the plunger **49** moves to the right, thus forming the conventional liquid spring wherein the plunger **49** is resiliently urged to the left out of the cylinder **47** by the pressure of the

liquid. A stop collar 54 is secured to the plunger 49 by a nut fastener 56 to prevent the plunger 49 from moving completely out of the gland 52.

The structure of the sea water actuator 26 is shown in Figure 7. The cylinder 27 is formed with a bore 57 into which projects the plunger 29. A cap 58 is bolted onto the open end of the cylinder 27 and is provided with a central aperture 59 through which the plunger 29 extends with a guiding engagement. The cap 58 is also formed with a plurality of openings 61 which provide communication between the left end of the cylinder bore 57 and the zone around the actuator 26. Mounted on the end of the plunger 29 is a piston head 62 provided with O-ring type seals 63 which provide a seal between the piston head 62 and the bore 57 so that the area within the cylinder 27 is divided into first and second chambers 64 and 66, respectively. Thus, the chamber 64 is exposed to the pressure of the water within the ballast tank through the opening 61 and the chamber 66 is isolated from the sea water. The chamber can be evacuated so that there will be no pressure therein acting on the piston or it may be desirable to connect the chamber 66 through a pressure line 67 to the inside of the submarine so that the pressure in the chamber 66 is also maintained at hull pressure and any leakage past the piston into the chamber 66 will not prevent the actuator from operating. When the submarine is on the surface, the pressure in the chamber 64 is substantially atmospheric pressure but as the submarine dives, the pressure of the water increases as a direct function of the depth of the submarine from the surface so that the plunger 29 is urged to the right by a force which is a function of the depth of the submarine.

The operation of the system can best be understood by referring to Figures 3 thru 5 which show the three major positions of the door 34 and door linkage. When the submarine is on the surface, the elements are in the position of Figure 3 wherein the springs 46 urge the rocker arms 39 in a counterclockwise direction and through the connection tie bars 42 urge the door 34 in a clockwise direction around the hinge pins 37 until the door 34 engages a stop 68 on the frame 19. Since the door 34 cannot move in a clockwise direction beyond its closed position relative to the frame 19 as shown in Figure 4, the rocker arms 39 are restrained against rotation relative to the door frame 19 by the tie bars 42. Therefore, the spring force tends to rotate the rocker arms 39 in a counterclockwise direction to the open position of Figure 3 and effects movement of the piston 62 toward the left in Figure 7, etc. If the submarine dives, the pressure builds up in the chamber 64 of the actuator 26 and overcomes the force of the springs 46 to rotate the door frame 19 in a clockwise direction until the stop surface 33 engages the cross bar 17. This is the position of the elements shown in Figure 4 wherein the ballast doors are closed because the door frame 19 is in its closed position relative to the base and the ballast door 34 is in its closed position relative to the frame. The liquid springs 46 and the sea water actuator 27 are sized so that the ballast doors are moved to the closed position when the submarine reaches a predetermined depth below the surface. Because the sea water actuator 26 is connected directly to the door frame 19, any additional force created by greater depths of the submarine will merely urge the stop surface 33 into tighter engagement with the cross bar 17 but will not cause any movement of the door.

When it is desired to surface the submarine, air under pressure is admitted into the upper portions of the ballast tanks creating a positive pressure in the tanks. This positive pressure acts on the doors 34 and creates a force which rotates the doors 34 in a counterclockwise direction against the action of the springs 46. The springs 46 are sized so that when a predetermined pressure acts on the doors 34, a sufficient force will be present to overcome the action of the springs 46 and rotate the door 34 in a counterclockwise direction relative to the door frame 19. This causes rotation of the rocker arms 39 through the connection of the tie bars 42 causing additional compression of the springs 46 until the position shown in Figure 5 is reached. As soon as sufficient water has passed out through the ballast doors to equalize the pressure in the ballast tanks with the pressure of the water surrounding the submarine, the springs 46 return the ballast door to its closed position of Figure 4. However, when the submarine reaches the surface, the actuator 26 does not produce a force to overcome the springs 46 so the frame 19 moves to the open position of Figure 3.

When the water flows into the tanks, it follows a flow direction shown by an arrow 71 which is the general direction from the ballast doors to the major portion of the ballast tanks. Conversely, when water flows out through the ballast doors, it follows the direction of the arrow 72 shown in Figure 5, which is substantially opposite to the direction of the arrow 71. Because the flow is along the same direction line for both entries and exhausted from the water of the ballast tanks and because this is the direction of normal flow into and out of the ballast tanks, a very low resistance is provided and smaller doors may be utilized for a predetermined flow capacity. Those skilled in the art will recognize that the use of the structure shown will provide a durable self-contained system wherein the forces are transmitted through rigid pivot connections that are substantially trouble free in operation. Also, a single spring force is utilized to bias both the door frame 19 and the door 34 thus reducing the structural complication of the system. It should be noted that two springs 46 are shown to provide a safety factor so that the system will continue to function even upon failure of one of the springs and also to provide symmetrical force application through the system. It should be understood, however, that it would be possible to operate the entire system with a single spring if desired.

Although a preferred embodiment of this invention is illustrated, it will be realized that various modifications of the structural details may be made without departing from the mode of operation and the essence of the invention. Therefore, except insofar as they are claimed in the appended claims, structural details may be varied widely without modifying the mode of operation. Accordingly, the appended claims and not the aforesaid detailed description are determinative of the scope of the invention.

I claim:

1. A compound door comprising a base, a frame pivoted on said base for movement between an open position and a closed position, a door pivoted on said frame for movement from an open position to a closed position relative to said frame, a spring having energy stored therein, a linkage operatively connecting said spring to said door and frame, said linkage transmitting forces from said spring to move said door from said open position to said closed position relative to said frame and move said frame to said open position, and an actuator operatively connected to said frame adapted under certain conditions of operation to move said frame to said closed position while said door remains closed relative to said frame by virtue of the forces of said spring.

2. A compound door comprising a base, a frame pivoted on said base for movement between an open position and a closed position, a door pivoted on said frame for movement from an open position to a closed position relative to said frame, a spring having energy stored therein, a linkage operatively connecting said spring to said door and frame, said linkage transmitting forces from said spring to move said door from said open position to said closed position relative to said frame and move said frame to said open position, and an actuator operated by water pressure connected to said frame moving said

frame to said closed position when the water pressure reaches a predetermined value while said door remains closed relative to said frame by virtue of the forces of said spring.

3. A compound door comprising a base, a door, and a door frame pivotally mounted on said base for movement of said door from a first to a second position relative to said frame and said frame from a first to a second position relative to said base, means carried by said base having energy stored therein, an energy transmitting mechanism between said means and said door and frame adapted to move said door from its first to its second position relative to said frame and to move said frame from its first to its second position relative to said base, and power means operatively connected to said frame adapted under certain conditions of operation to remove said frame from its second to its first position relative to said base while said door remains in its second position relative to said frame by virtue of the energy transmitted thereto by said mechanism.

4. A compound door comprising a base, a frame pivoted on said base for movement between open and closed positions relative to said base, a door pivoted on said frame for movement between open and closed positions relative to said frame, a liquid spring carried by said base, means operatively connecting said spring to said door and frame adapted to transmit forces upon expansion of said spring to move said door to its closed position and to move said frame to its open position, and an actuator operatively connected to said frame adapted under certain conditions of operation to move said frame to its closed position by compressing said spring while said door remains in its closed position by virtue of said forces transmitted thereto.

5. The compound door comprising a base having a door opening, a frame pivoted in said opening for movement between a closed position and an open position, a door pivoted on said frame for movement relative thereto from a closed position to an open position, said door closing said opening only when said frame is in said closed position and said door is in said closed position, a spring, a linkage connecting said spring to said frame and door biasing said frame toward said frame open position and said door towards said door closed position, and an actuator connected to said frame and operable to overcome said spring and move said frame to said frame closed position.

6. The compound door comprising a base, a frame pivoted on said base for movement between a frame closed position and a frame open position displaced in one direction from said frame closed position, a door pivoted on said frame for movement relative thereto from a door closed position to a door open position spaced from said door closed position in a direction opposite from said one direction, a spring connected to said base, a linkage connecting said spring to said door and frame biasing said door toward said door closed position and said frame towards said frame open position, and an actuator connected to said frame operable to overcome said spring and move said frame to said frame closed position.

7. A ballast door comprising a base, a frame pivoted on said base, first inter-engaging stop surfaces on said frame and base limiting rotation of said frame in one direction, a door pivoted on said frame, second inter-engaging stop surfaces on said door and frame limiting rotation of said door relative to said frame in a direction frame, a connection between said door and rocker arm opposite said one direction, a rocker arm pivoted on said frame, a connection between said door and rocker arm effecting rotation of said door relative to said frame when said rocker arm rotates relative to said frame, a spring connected to said rocker arm biasing it in a direction resiliently urging said second stop surfaces into engagement and thereafter urging said frame in a direction separating said first stop surfaces, and an actuator connected to said frame operable to rotate said frame against the action of said spring bringing said first stop surfaces into engagement.

8. A submarine ballast door comprising a base, a frame pivoted on said base, first inter-engaging stop surfaces on said frame and base limiting rotation of said frame in one direction, a door pivoted on said frame, second inter-engaging stop surfaces on said door and frame limiting rotation of said door relative to said frame in a direction opposite said one direction, a rocker arm pivoted on said frame, a connection between said door and rocker arm effecting rotation of said door relative to said frame when said rocker arm rotates relative to said frame, a spring connected to said rocker arm normally rotating it in a direction moving said second stop surfaces into engagement and thereafter moving said frame in a direction separating said first stop surfaces, and an actuator connected to said frame operable when the submarine reaches a predetermined depth to rotate said frame against the action of said spring bringing said first stop surfaces into engagement.

9. A ballast door comprising a base, a frame pivoted on said base, first inter-engaging stop surfaces on said frame and base limiting rotation of said frame in one direction, a door pivoted on said frame spaced from the pivot of said frame, second inter-engaging stop surfaces on said door and frame limiting rotation of said door relative to said frame in a direction opposite said one direction, a rocker arm pivoted on said frame, a tie bar connecting said door and rocker arm effecting rotation of said door relative to said frame when said rocker arm rotation relative to said frame, a spring connected to said rocker arm biasing it in a direction resiliently urging said second stop surfaces into engagement and thereafter urging said frame in a direction separating said first stop surfaces, and an actuator connected to said frame operable to rotate said frame against the action of said spring bringing said first stop surfaces into engagement.

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