

Nov. 17, 1942.

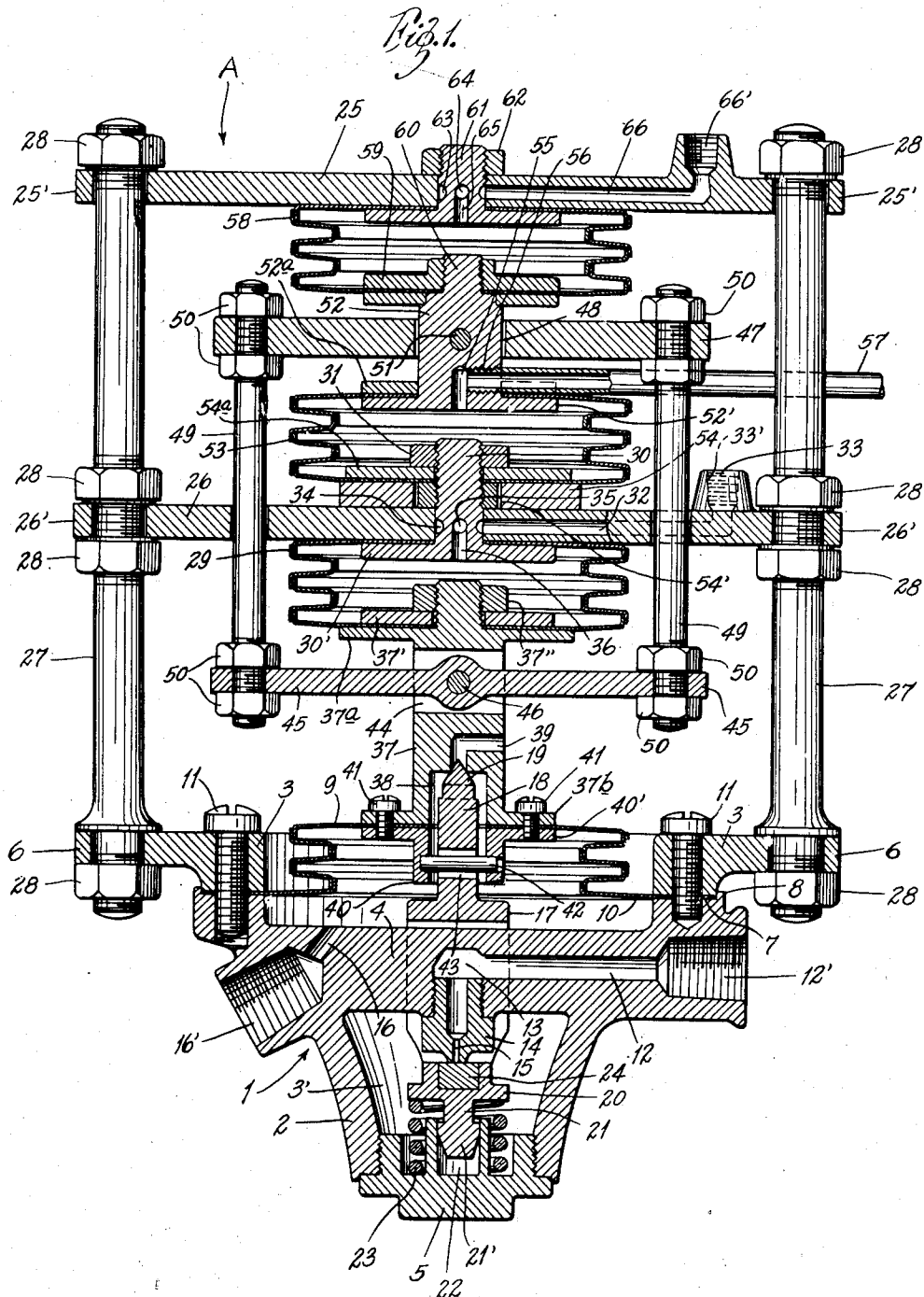
A. J. FAUSEK ET AL

2,302,014

PRESSURE-CONTROLLED OPERATING APPARATUS

Filed Aug. 3, 1942

2 Sheets-Sheet 1



INVENTORS:
ARTHUR J. FAUSEK,
IRVING F. FAUSEK,
BY *Emmington*

Nov. 17, 1942.

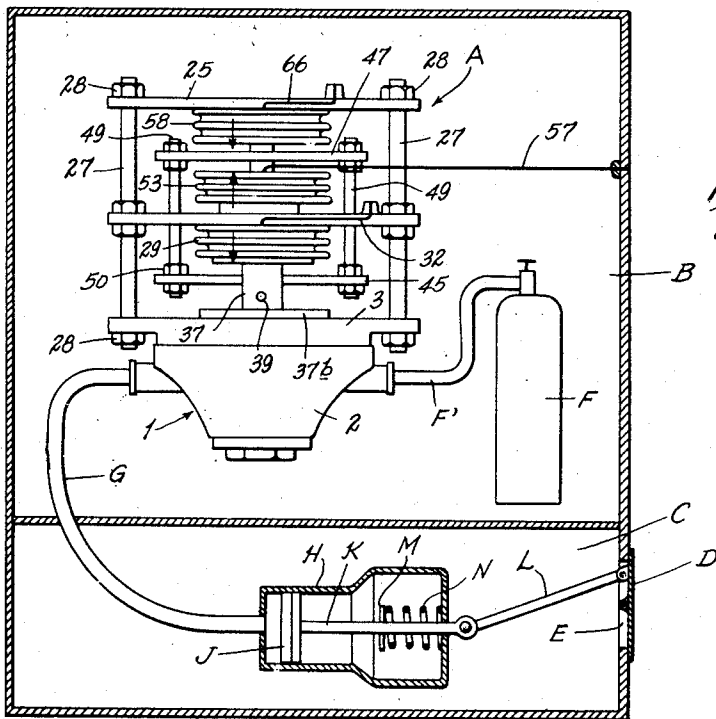
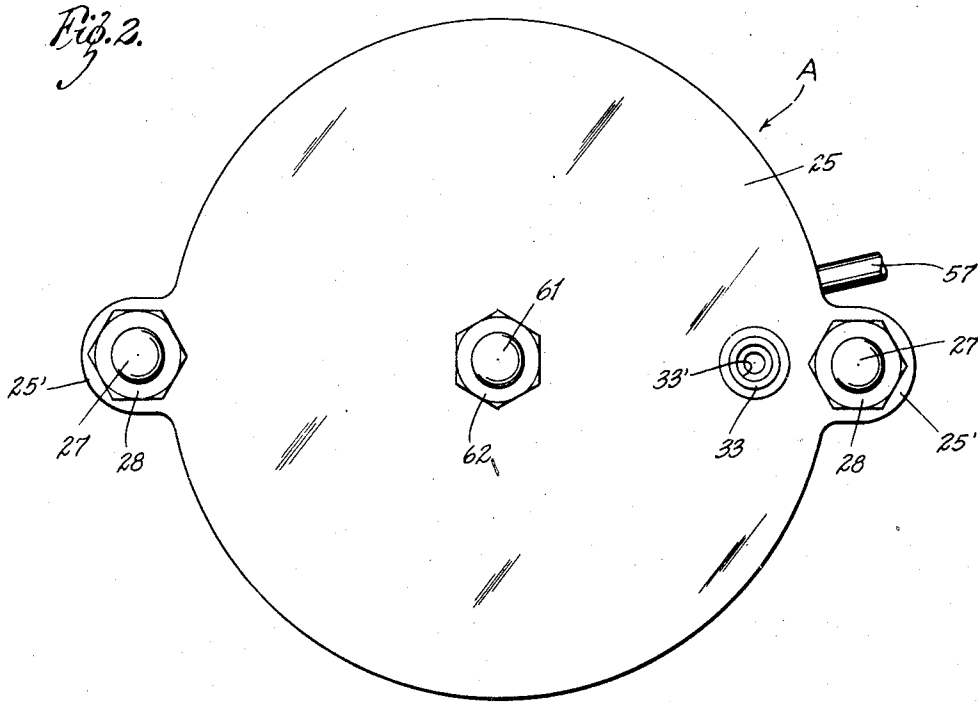
A. J. FAUSEK ET AL

2,302,014

PRESSURE-CONTROLLED OPERATING APPARATUS

Filed Aug. 3, 1942

2 Sheets-Sheet 2



INVENTORS:
ARTHUR J. FAUSEK,
IRWING F. FAUSEK,
BY *Wm. Harrington*
ATTORNEY.

UNITED STATES PATENT OFFICE

2,302,014

PRESSURE-CONTROLLED OPERATING
APPARATUSArthur J. Fausek and Irwing F. Fausek,
Clayton, Mo.

Application August 3, 1942, Serial No. 453,356

10 Claims. (Cl. 137—153)

This invention relates generally to pressure-controlled operating mechanisms and more specifically to an improved apparatus which is operable in response to action of pressure existing within parts of the apparatus to regulate flow of fluid which serves to actuate a device whose operation is controlled by the improved operating apparatus, the predominant object of the invention being to provide an improved apparatus of the type referred to which is of simple construction and is capable of performing its intended function in a highly efficient manner.

The improved apparatus of the present invention is adapted for various uses, and in order that its operation may be understood we choose to describe herein, in brief form, a use of the improved apparatus where it is employed with a submarine boat for the purpose of automatically actuating valves, or other operable parts of the boat structure, in response to differences in pressure of atmosphere within the interior of the boat and water exterior of the boat, the particular function performed by the improved apparatus in the use thereof which is described herein being to control actuation of valves which regulate passage of water into and out of the ballast tanks of the submarine boat.

Fig. 1 is a vertical section of the improved apparatus.

Fig. 2 is a plan view of the apparatus illustrated in Fig. 1.

Fig. 3 is a diagrammatical view showing one use of the improved apparatus where it is employed in association with a submarine boat.

In the drawings, wherein is shown for the purpose of illustration, merely, one embodiment of the invention, A designates the improved apparatus gradually. The apparatus A includes a pressure regulator 1 which is produced by a lower body portion 2 and an upper body portion 3. The lower body portion 2 is of hollow formation, providing a chamber 3' therein, and extended transversely of said chamber is a bridge portion 4 which extends from one to an opposite side wall portion of the lower body portion 2. The bridge portion 4 is substantially smaller in cross-section than the diameter of the chamber 3' so that portions of the chamber which are disposed at opposite sides of the bridge portion serve to connect the portions of the chamber that are located below and above the bridge portion. The chamber 3' is closed at the bottom of the lower body portion 2 by a cap 5 which is disposed in screwthreaded engagement with the lower portion of said lower body portion.

The upper body portion 3 of the regulator 1 is in the form of a ring which is provided with outwardly projected ears 6 that are located at opposite sides of said upper body portion 3, said upper body portion being supported by an annular seat 7 which is formed at the upper portion of the lower body portion 2, and an annular, upstanding, marginal flange 8 being formed on said lower body portion at the top thereof which embraces the lower part of the upper body portion and centers said upper body portion with respect to the upper part of the lower body portion. The pressure regulator 1 includes a diaphragm 9 which is provided with a lower, outwardly projected, annular extension 10 that is clamped between the lower and upper body portions 2 and 3 of said pressure regulator 1, a plurality of fastening devices 11 being employed to secure the lower and upper body portions together and to clampingly engage the annular extension 10 of the diaphragm therebetween. The diaphragm 9 is produced by an assembly of diaphragm sections suitably secured together, said diaphragm including an upper wall, an annular side wall of corrugated formation, and the outwardly projected extension 10 previously mentioned, and the interior of said diaphragm is in communication with the chamber 3' of the body portion of the pressure regulator 1.

Formed longitudinally through the bridge portion 4 is an inlet passageway 12 which at its outer end is in the form of an enlarged portion 12' provided with a screwthreaded wall. The inlet passageway 12 terminates at its inner end in a cavity 13 provided with a screwthreaded wall and threaded into the open lower portion of said cavity 13 is a nozzle 14 provided with an opening formed therethrough which terminates in a discharge orifice 15. The pressure regulator 1 includes, also, a discharge passageway 16 which opens into the chamber 3' at its inner end and terminates at its outer end in an enlarged portion 16' provided with a screwthreaded wall.

Arranged in embracing relation with respect to the bridge portion 4 of the pressure regulator 1 is a yoke 17, the portion of said yoke which overlies said bridge portion 4 having an extension 18 projected upwardly therefrom which terminates at its upper end in a conical valve stem 19. At the lower end portion of the yoke 17 a member 20 is suitably fixed thereto and this member is provided with a downwardly extended guide 21 having an enlarged head portion 21' which is disposed for sliding movement in a guideway 22 which is projected upwardly

from the cap 5. A coil spring 23 is arranged in embracing relation with respect to the guideway 22, and the opposite ends of said coil spring contact, respectively, with a portion of the member 20 and with a portion of the cap 5. The coil spring 23 serves to stabilize movement of the lower portion of the yoke 17. Additionally, the member 20 has formed therein a cavity in which is disposed an insert 24 that serves as a valve seat which is adapted to contact with the discharge end of the nozzle 14.

Disposed at the upper end of the apparatus A is a plate 25 which in plan is of generally circular shape and which has extended outwardly from opposed sides thereof a pair of ears 25'. Likewise, the apparatus A includes a similar plate 26 which is spaced downwardly from the plate 25 and is provided with a pair of ears 26' extended outwardly from opposed sides thereof. The plates 25 and 26, and the upper body portion 3 of the pressure regulator are rigidly connected together by a pair of tie rods 27 having portions which extend through openings formed through the ears 25', 26', and 6 of said plates 25 and 26 and said upper body portion 3, said tie rods being provided with flanges 27' which contact with the top faces of the ears of the upper body portion 3, and nuts 28, which are mounted on said tie rods, being arranged in engagement with the bottom faces of the ears of the upper body portion 3, with the top faces of the ears of the plate 25, and with top and bottom faces of the ears of the plate 26.

Secured to and disposed beneath the plate 26 is a diaphragm 29 which is made up of an assembly of diaphragm sections suitably secured together, said diaphragm including a top wall, a bottom wall and an annular side wall of corrugated formation. The diaphragm 29 is secured to the plate 26 by a bolt 30 which is provided with an enlarged head portion 30', the shank of said bolt extending upwardly through aligned openings formed through the top wall of the diaphragm 29 through the plate 26, and through associated parts of the apparatus and a nut 31 being screwed on the upper screwthreaded shank of the bolt 30 so as to clamp a portion of the top wall of the diaphragm 30 between the head of the bolt and the lower face of the plate 26. The plate 26 has formed therein an inlet passageway 32 which leads from an upwardly extended projection 33 which is formed on the plate 26 at the top face thereof and is provided with an opening 33' that communicates with the inlet passageway 32 and is provided with a screwthreaded wall, said screwthreaded opening being adapted, if desired, to receive a screwthreaded end portion of a pipe or other conductor (not shown). The inner end portion of the inlet passageway 32 terminates at an annular channel 34 formed at the surface of the shank of the bolt 30, there being a cross passageway 35 which connects said annular channel 34 with a passageway 36 that extends longitudinally of the stem of the bolt and which is open at the lower surface of the head of the bolt.

Secured to the lower wall of the diaphragm 29 and extended downwardly therefrom is a member 37, said member being provided with an annular flange 37a at its upper end, a portion of the lower wall of the diaphragm 29 being clamped between said flange and a plate 37' by a nut 37''. At its lower end the member 37 is provided with an outwardly extended, annular flange 37b which is secured to the top wall

of the diaphragm 9. The lower portion of the member 37 has a cavity 38 formed therein which is open at the lower end of said member, and arranged in communication with said cavity at its upper end is an angular passageway 39, the outer end of said angular passageway being open at a side of the member 37. As is shown in Fig. 1 the angular passageway 39 is of substantially less diameter than the cavity 38 and the junction of the wall of the angular passageway 39 and the top wall of the cavity 38 provides a rectangular valve seat with which the conical valve stem 19 of the extension 18 of the yoke 17 is adapted to contact. Also, the top wall of the diaphragm 9 has secured thereto a tubular element 40 which is provided at its upper end with an annular, outstanding flange 40', said tubular element and the member 37 being secured to the top wall of said diaphragm 9 by fastening devices 41 which extend through aligned apertures formed in the flanges of said tubular element and said member and in the top wall of said diaphragm 9. The tubular element supports a transversely extended pin 42 which passes through an enlarged opening 43 formed through the extension 18 of the yoke 17.

The member 37 has formed therethrough an opening 44 through which is extended the central portion of a plate 45, said plate being secured to said member 37 by a pin 46 that passes through an opening formed through the central portion of the plate and is seated in apertures formed in portions of the member 37 located at opposite sides of the opening 44. Arranged in vertical spaced relation with respect to the plate 45 is a somewhat similar plate 47 which has formed therethrough centrally thereof an opening 48. The opposite end portions of the plates 45 and 47 are connected together by tie rods 49 and the nuts 50 associated therewith, and the plate 47 is secured by a pin 51 to an element 52 which is extended through the opening 48 of said plate 47.

The element 52 is provided at its lower end with an outstanding flange 52', between which flange 52 and a plate 52a is secured a portion of the top wall of a diaphragm 53, said diaphragm being made up of a plurality of assembled diaphragm sections suitably secured together. The diaphragm 53 includes the top wall referred to, a bottom wall, and a side wall of corrugated formation, the bottom wall of said diaphragm being clamped between a spacer 54 which contacts with the top face of the plate 26 and a plate 54a, and said spacer being provided with a centrally located opening 54' through which the bolt 30 extends. The plate 54a contacts with the top face of the bottom wall of the diaphragm 53 and the shank of the bolt 30 extends through an opening located centrally of said plate 54a, the nut 31 of said bolt 30 contacting with the top face of said plate 54a. The element 52 has formed therein in its lower portion a passageway 55 which is open at the lower face of said element, and said element 52 has also formed thereon a screwthreaded opening 56 which extends at an angle to said passageway in communication therewith, and a screwthreaded end portion of a conductor 57 is screwed into said screwthreaded opening.

Disposed between the plate 25 and the plate 47 is a diaphragm 58 which is formed from a plurality of assembled diaphragm sections suitably secured together, said diaphragm comprising a top wall, a bottom wall, and an annular side wall

of corrugated formation. The bottom wall of the diaphragm 58 is secured to the element 52 by a flanged, clamping member 59 which is screw-threadedly mounted on an upstanding, threaded stem 60 formed on the element 52, said bottom wall of the diaphragm being provided with an opening through which said stem 60 extends and a portion of said bottom wall of the diaphragm which surrounds said opening being clamped between the lower face of the clamping member 59 and the top face of the element 52. The top wall of the diaphragm 58 is secured to the plate 25 by a clamping member 61 which includes a lower flange portion and a stem extended upwardly from said flange portion, said stem being extended through aligned openings formed through the top wall of the diaphragm 58 and the plate 25. The upper portion of the stem of the clamping member 61 is screwthreaded and a nut 62 is mounted on this screwthreaded portion of the stem, said nut contacting with the top face of said plate 25 and serving to draw the clamping member upwardly so that a portion of the top wall of the diaphragm 58 is clamped between the top face of the flange portion of the clamping member and the lower face of the plate 25.

The stem portion of the clamping member 61 has formed therein at its outer face an annular channel 63, and extended transversely of said stem portion of said clamping member is a passageway 64 which communicates at its opposite ends with said annular channel, said clamping member 61 also being provided with a duct 65 which communicates with said transverse passageway 64 and is open at the lower face of the clamping member 61. Formed in the plate 25 is a passage 66 which communicates at its inner end with the annular channel 63 and terminates at its outer end in an enlarged portion 66' formed in an upwardly projected extension formed on the plate 25.

In Fig. 3 is illustrated a diagrammatical view which illustrates one use for the improved apparatus of the present invention, and with regard to this view it will be assumed that the compartment B is the interior of a submarine boat, that the space C is the interior of a ballast tank of a submarine boat, and that the valve D controls passage of water from the exterior of the submarine boat through the opening E into the ballast tank C. It is to be noted from inspection of Fig. 3 that the passageway 66 leading to the interior of the diaphragm 58 has sealed therein sufficient pressure to make it operable, and it is to be noted also that the conductor 57 is open at its outer end to the exterior of the submarine boat, or, at least, is subject to pressure influence of water exterior of the submarine. Also, the passageway 32 leading to the diaphragm 29 conducts operative pressure into said diaphragm 29 to provide a predetermined pressure in said diaphragm 29. Likewise Fig. 3 illustrates a container F for air, or other medium, under pressure, with a conductor F' leading from said container F to the inlet passageway 12 of the pressure regulator 1 of the apparatus A, and also this view illustrates a conductor G which leads from the discharge passageway 16 of the pressure regulator 1 to a cylinder H. The cylinder H has arranged therein for reciprocatory movement a piston J to which is fixed for movement therewith a piston rod K that passes through an opening formed through an end wall of the cylinder, said piston rod having pivotally at-

tached thereto a link L which is pivoted at its opposite end to the valve D. Additionally, the piston rod K supports a pin M that provides an abutment for a coil spring N whose opposite end abuts against the end wall of the cylinder through which the piston rod extends. The coil spring N is maintained under compression so that it tends to move the piston to the left in Fig. 3.

In the use of the improved apparatus disclosed herein and as illustrated in Fig. 3, the diaphragm 29 contains therein a predetermined pressure which, when said pressure is greater than the pressure within the chamber 3', flexes or expands the diaphragm 29 downwardly. Such downward movement of the lower portion of the diaphragm 29 transmits corresponding downward movement to the yoke 17, thereby moving the valve seat 24 away from the lower end of the nozzle 14 and permitting high pressure gas or liquid to flow into the chamber 3' of the pressure regulator 1. When the pressure within the chamber 3' equals the pressure within the diaphragm 29, the diaphragm 9 flexes upwardly thereby restoring the diaphragm 29 to its original condition and the coil spring 23 seats the valve seat 24 against the lower end of the nozzle 14 to interrupt passage of high pressure gas or liquid into the chamber 3'. This sequence of operations is followed through each time pressure is withdrawn from the chamber 3' to perform work, the reduced pressure within the chamber 3' permitting the diaphragm 29 to be flexed downwardly by the greater pressure contained therein to open the nozzle 14 and cause high pressure fluid to flow into the chamber 3' until the pressure within the chamber 3' equals the pressure within the diaphragm 29, whereupon the diaphragm 9 is flexed upwardly to restore the diaphragm 29 to its original condition and the coil spring 23 seats the valve seat 24 against the lower end of the nozzle 14 to interrupt passage of high pressure fluid into the chamber 3'.

The diaphragm 58 has sealed therein atmosphere, gas, or other medium under a predetermined pressure, and the diaphragm 53 receives pressure in response to water pressure exterior of the submarine boat through the conductor 57 which is subject to pressure influence exterior of the submarine boat. It is to be noted that the diaphragm 53 operates in the opposite direction to the direction of operation of the diaphragm 29; that is to say the diaphragm 29 expands downwardly while the diaphragm 53 expands upwardly. This is true also of the diaphragms 29 and 9 and of the diaphragms 53 and 58, the diaphragm 29 expanding downwardly and the diaphragm 9 expanding upwardly, while the diaphragm 53 expands upwardly and the diaphragm 58 expands downwardly.

It will be assumed, in the use of the improved apparatus disclosed herein, that it is desired to submerge a submarine boat equipped with the apparatus to a depth of one hundred feet. In this event pressure is introduced into the diaphragm 29 to produce therein a pressure equal to the water pressure at a depth of one hundred feet and such pressure within the diaphragm 29 will expand said diaphragm downwardly to move the yoke 17 downwardly and consequently move the valve seat 24 away from the lower end of the nozzle 14. As the pressure builds up within the chamber 3' of the pressure regulator 1 the piston J will be moved to the right in Fig. 3 to open the valve D and thus admit water exterior

of the submarine boat into the ballast tanks of the boat to cause the submarine boat to submerge. During downward submerging movement of the submarine boat the pressure within the diaphragm 53, which is influenced by pressure influence exterior of the submarine boat will increase in accordance with the increased water pressure at the lower levels through which the submerging boat passes until the submarine boat reaches the desired one hundred feet level when the pressure within the diaphragm 55 will be approximately the same as the pressure within the diaphragm 29. As the pressure within the diaphragm 53 increases slightly beyond the pressure within the diaphragm 29 it will over-balance the diaphragm 53 will expand upwardly to collapse the diaphragm 29 and draw the valve seat 24 against the lower end of the nozzle 14 to interrupt flow of pressure producing medium into the chamber 3' and into the cylinder H. As the valve seat is seated against the lower end of the nozzle 14 by the greater pressure within the diaphragm 53 this greater pressure continues to move the member 37 upwardly, and flexes the diaphragm 9 in an upward direction, with the result that the valve seat within the member 37 is drawn upwardly away from the valve stem 19 to open the bleeder port 39. With this situation prevailing the coil spring N will return the piston J to its left-hand position within the cylinder H thereby closing the valve D and forcing the pressure-producing medium from the cylinder and through the conductor G into the chamber 3' whence said pressure-producing medium bleeds through the bleeder port 39.

There is a possibility that the air pressure prevailing within a submarine having the improved apparatus associated therewith may vary, and in order to compensate for such condition the diaphragms 9, 29, 53 and 58 are so related that variation of air pressure within the submarine is rendered ineffective insofar as its effect on the apparatus is concerned. This situation is brought about by the fact that the diaphragms 9 and 29 are based on opposed bases and operate in opposite directions and therefore external pressures acting on said diaphragms are rendered ineffective by affecting both diaphragms to some degree. Likewise, the diaphragms 53 and 58 are based on opposed bases and operate in opposite directions, and therefore external pressure applied to said diaphragms 53 and 58 will affect both of said diaphragms equally so as to render such external pressure ineffective.

From the foregoing it is plain that the descent of a submarine boat to a desired depth is controlled automatically, all that need be done being to introduce the proper pressure into the diaphragm 29 by operating a valve (not shown) which will control flow of the pressure-producing medium from a source of supply into said diaphragm and by watching a gage (not shown) which will indicate when the proper pressure has been established within the diaphragm 29. When the proper pressure has been established within the diaphragm 29 the subsequent operation of the apparatus is automatic and the descent of the submarine will be arrested at the desired depth. When a submerged submarine equipped with the improved apparatus is to be brought to the surface its ballast tanks are blown out in the usual manner to affect such ascent.

We claim:

1. A pressure-responsive apparatus comprising

a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm adapted to be acted on by pressure trapped at said second diaphragm for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm adapted to be acted on by a pressure-producing influence originating external to the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operated by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway.

2. A pressure-responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm adapted to be acted on by pressure trapped at said second diaphragm for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm adapted to be acted on by a pressure-producing influence originating external to the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operated by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway, said diaphragm of said pressure regulator and said second diaphragm being supported on independent bases and being adapted to be flexed in opposite directions.

3. A pressure-responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm adapted to be acted on by pressure trapped at said second diaphragm for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm adapted to be acted on by a pressure-producing influence originating external to the

apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operated by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway, said diaphragm of said pressure regulator and said second diaphragm being supported on independent bases and being adapted to be flexed in opposite directions, and said third diaphragm being adapted to be flexed in a direction opposite to the direction in which said second diaphragm is flexed.

4. A pressure-responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm adapted to be acted on by pressure trapped at said second diaphragm for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm adapted to be acted on by a pressure-producing influence originating external to the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a fourth diaphragm coacting with said third diaphragm and subjected to pressure trapped at said fourth diaphragm, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operated by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway.

5. A pressure-responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm adapted to be acted on by pressure trapped at said second diaphragm for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm adapted to be acted on by a pressure-producing influence originating external to the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a fourth diaphragm coacting with said third diaphragm and subjected to pressure trapped at said fourth diaphragm, said third diaphragm and said fourth diaphragm being supported on independent bases and being adapted to be flexed in opposite directions, a discharge passageway by way of which

pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operated by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway.

6. A pressure responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm adapted to be acted on by pressure trapped at said second diaphragm for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm adapted to be acted on by a pressure-producing medium originating external to the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a fourth diaphragm coacting with said third diaphragm and subjected to pressure trapped at said fourth diaphragm, said diaphragm of said pressure regulator and said second diaphragm being supported on independent bases and being adapted to be flexed in opposite directions, said third diaphragm being adapted to be flexed in a direction opposite to the direction in which said second diaphragm is flexed, and said third and fourth diaphragms being supported on independent bases and being adapted to be flexed in opposite directions, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operated by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway.

7. A pressure responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm of hollow structure adapted to be acted on by pressure trapped therein for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm of hollow structure adapted to be acted on by a pressure-producing medium therein, said third diaphragm being open to a pressure-producing medium external of the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a fourth diaphragm of hollow structure coacting with said third diaphragm and subjected to pressure trapped therein, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operable by said third diaphragm for con-

trolling passage of pressure-producing medium for said chamber of said pressure regulator by way of said discharge passageway.

8. A pressure responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passageway of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm of hollow structure adapted to be acted on by pressure trapped therein for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm of hollow structure adapted to be acted on by a pressure-producing medium therein, said third diaphragm being open to a pressure-producing medium external of the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a fourth diaphragm of hollow structure coacting with said third diaphragm and subjected to pressure trapped therein, said diaphragm of said pressure regulator and said second diaphragm being supported on independent bases and being adapted to be flexed in opposite directions, said third diaphragm being adapted to be flexed in a direction opposite to the direction in which said second diaphragm is flexed, and said third and fourth diaphragms being supported on independent bases and being adapted to be flexed in opposite directions, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operable by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway.

9. A pressure responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm of hollow structure adapted to be acted on by pressure trapped therein for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm of hollow structure adapted to be acted on by a pressure-producing medium therein, said third dia-

phragm being open to a pressure-producing medium external of the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a fourth diaphragm of hollow structure coacting with said third diaphragm and subjected to pressure trapped therein, means for mechanically connecting said second, third, and fourth diaphragms to said means for controlling passage of pressure-producing medium into the chamber of said pressure regulator, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operable by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway.

10. A pressure responsive apparatus comprising a pressure regulator having a chamber, said pressure regulator including an inlet passageway leading into said chamber, an outlet passageway leading from said chamber, means for controlling passage of pressure-producing medium into said chamber by way of said inlet passageway, and a diaphragm for actuating said controlling means in response to change in pressure within said chamber, a second diaphragm of hollow structure adapted to be acted on by pressure trapped therein for operating said controlling means to permit pressure-producing medium to flow into the chamber of said pressure regulator by way of said inlet passageway, a third diaphragm of hollow structure adapted to be acted on by a pressure-producing medium therein, said third diaphragm being open to a pressure-producing medium external of the apparatus and operable to actuate said controlling means to prevent flow of pressure-producing medium into said chamber of said pressure regulator by way of the inlet passageway thereof, a fourth diaphragm of hollow structure coacting with said third diaphragm and subjected to pressure trapped therein, means for mechanically connecting said second, third, and fourth diaphragms to said means for controlling passage of pressure-producing medium into the chamber of said pressure regulator, a coil spring for urging said means for controlling passage of pressure-producing medium into the chamber of said pressure regulator toward a position where such passage of said medium is prevented, a discharge passageway by way of which pressure-producing medium may escape from said chamber of said pressure regulator, and valve means operable by said third diaphragm for controlling passage of pressure-producing medium from said chamber of said pressure regulator by way of said discharge passageway.

ARTHUR J. FAUSEK.
IRWING F. FAUSEK.