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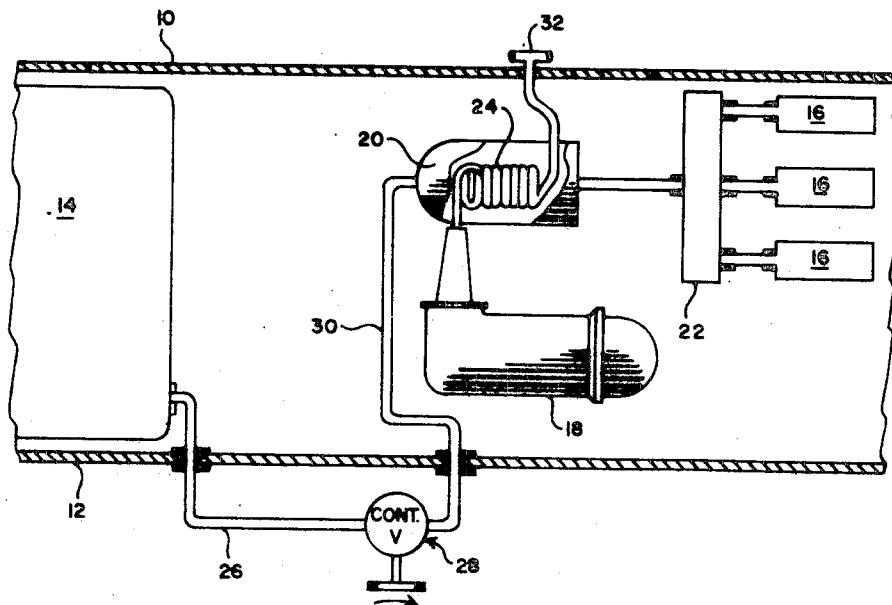
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[54] **HOT GAS AUGMENTED BALLAST EXPULSION
 SYSTEM**
 3 Claims, 1 Drawing Fig.

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ABSTRACT: An improved compressed air ballast expulsion system for submersible craft with a thermal augmentation system for the working fluid so as to increase the expulsion work and rate thereof. A gas generator surrounds the conduit between an air tank and a ballast tank. The gas generator discharges the hot gases externally of a submersible.



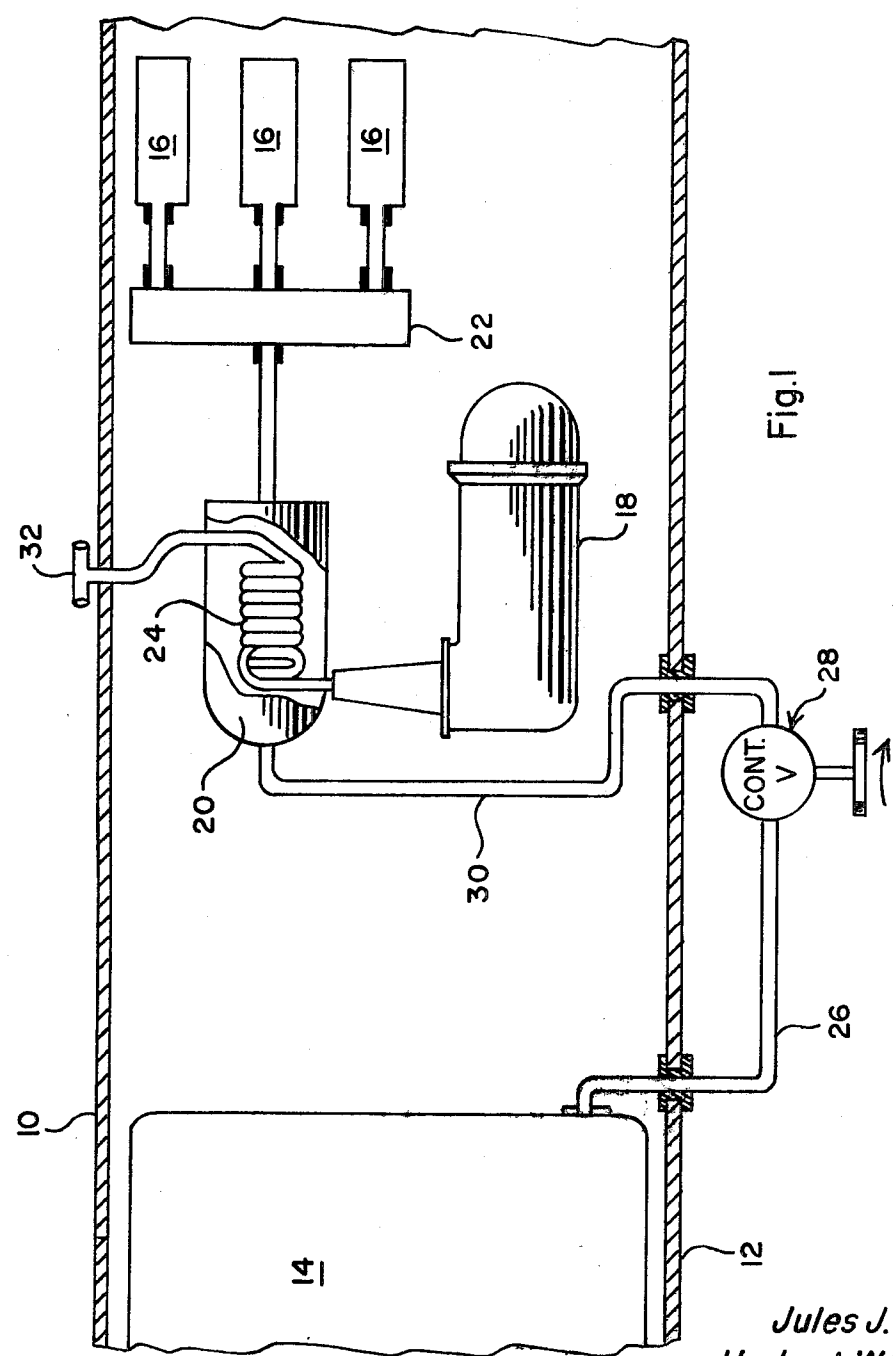


Fig. 1

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HOT GAS AUGMENTED BALLAST EXPULSION SYSTEM

This invention relates generally to deballasting systems and more particularly to a compressed air expulsion system for submarines and other submersible craft which will provide a unique safety potential therefor.

It has been said, ask any submariner, that most submarines have only enough expulsion air on board for emergency deballasting and trimming operations to meet one third of their immediate requirements above collapse depth, that is, about one-third of the tankage required to move them from virtual disaster to a position of neutral buoyancy, but not to the surface.

An increase in expulsion air capacity has required a penalty of weight which becomes of increasing significance as the depth of submersion increases since greater capacity, storage vessels, piping, etc. are necessary to provide additional blowing air. The air storage capacity and crew safety must therefore be compromised because the expulsion work which is accomplished by the available air is severely limited. The air must be stored at very high pressure and, because of flow restrictions, is inherently cooled from -200° to -250° F. when vented into sea water ballast tanks. The high-pressure air is contained in storage tanks positioned outside the pressure hull and is piped through the hull into a delicate flow control mechanism that supplies a metered volume back through the pressure hull to blow ballast from the water tanks.

Prior efforts to increase expulsion work have not been feasible or successful. For example, one effort was the use of solid propellants and the mixing of their hot propellant gases of more than 2000° F. with high-pressure air as it entered the pressure hull through the flow control mechanism and out again to the ballast tanks. This merely created a myriad of problems of compatibility with the submarines piping network and steel integrity of the pressure hull and outer envelope.

Accordingly, the main object of the present invention is to provide a system for and method of augmenting the expulsion air for the ballast tanks of submersible craft which solves the problem in question and obviates the difficulties of prior unsuccessful solutions.

An important object of the present invention is to provide a hot gas augmented ballast expulsion system which aids in the expulsion of water by increasing the expulsion effort of the compressed air while simultaneously advancing the rate at which the water can be pushed, or expelled from the ballast tanks.

Another important object of the present invention is to provide a ballast expulsion system of the type described in which heat is exchanged into the metered air outside of the pressure hull without contamination of interior piping and without degrading hull integrity by employing a closed-cycle heat exchanger also outside the pressure hull.

A further important object of the present invention is to provide an augmented ballast expulsion system in which propellants are burned to produce hot gases from which heat is transferred into the compressed air stream after the air has passed the flow control mechanism and back outside the pressure hull and is on its way to the manifold of the ballast tanks, the heat furnishing gases then being vented overboard.

Other objects and advantages of the present invention will become apparent during the course of the following description.

In the drawing, one embodiment of the invention is disclosed in a fragmentary schematic view thereof.

Referring to the drawing, there is shown the outer hull 10 of a submersible having an inner or pressure hull 12 spaced therefrom. One or more compressed air storage tanks 14, diagrammatically shown ballast and trim water tanks 16 are mounted between the hulls as is a gas generator 18, a heat exchange chamber 20 (partially broken away) terminating in a manifold 22 and a heat exchange coil 24 mounted in the chamber.

It will be understood that conventionally when it is desired to trim the attitude of a submersible or to increase its buoyan-

cy to approach the surface, compressed air is permitted to flow from tanks 14 through a conduit 26 through pressure hull 12 to a sensitive flow control mechanism 28, generally operated by ships personnel, which meters the compressed airflow and conducts it back through pressure hull 12 by a conduit 30 to Chamber 20 and thence to manifold 22. It is then distributed to ballast and trim tanks 16 in predetermined proportions through control mechanisms (not shown).

In order to materially and thermally augment the expulsion air in accordance with the present invention, conduit 30 is connected to the heat exchange chamber 20 forming the upstream end of manifold 22 so that the manifold 22 bound high-pressure air is forced to flow over the closed-circuit heat exchange coil 24 which is connected to the aft end of gas generator 18. The downstream end 32 of coil 24 discharges or vents the hot products of combustion produced by generator 18 overboard as indicated in the FIGURE.

The thermal augmentation of the working fluid or air as disclosed in this application is based upon Charles Law which states that the weight of water to be displaced by a given weight of air at any pressure, determined by the depth of submergence, is directly proportional to the absolute temperature of the air.

As stated, the hot gases are formed in generator 18 by combustion of one or more propellants on a start-stop basis upon demand in accordance with controls (not disclosed) which may be coordinated with flow control mechanism 28 if desired.

The heat transfer from the hot gases of combustion passing through coil 24 to the compressed air passing through heat exchange chamber 20 on the way to manifold 22 is such as to provide a very substantial augmentation to the expulsion air.

It will be noted that the hot gases have no path to penetrate pressure hull 12 of the submersible because it is not mixed with the high-pressure air to thus eliminate a risk present in currently conceived systems. The problem of pressure surge is also eliminated by venting overboard as are the possibilities of overheating and corrosive effects to weaken the hull structure.

It will now be apparent that the system for and method of ballast expulsion described herein materially increases the quantity of ballast water and the rate at which it can be expelled from the ballast tanks by the thermally augmented air; eliminates the risk of hot gas being ducted into the pressure hull; permits the use of hotter gas at higher pressure; and simplifies the method by which the flow of hot gas is usually terminated by simply venting it overboard.

What is claimed is:

1. A water ballast expulsion system for submersibles having an outer hull and an inner pressure hull spaced therefrom comprising, in combination, a compressed air tank and a ballast tank mounted at spaced points between said hulls; a conduit connecting said tanks and including an airflow control mechanism therein, said airflow control positioned in said tank conduit internally of said pressure hull and said connecting conduit passing from said air tank through said pressure hull internally thereof to said airflow control and thereafter back through said pressure hull to said ballast tank; a heat exchanger in said tank conduit between said ballast tank and said air tank within said outer and inner hulls; a hot gas generator positioned between said hulls; a hot gas conduit connected to said generator and passing within said exchanger and through said outer hull of said submersible and terminating externally thereof; and means for discharging said hot gas from said gas generator externally of said submersible.

2. The combination of claims 1 wherein the hot gas is developed from the combustion of at least one propellant.

3. The method of augmenting ballast expulsion from a submersible, said submersible having an outer hull and an inner pressure hull and including ballast expelling compressed air and a tank therefor, a water ballast tank, conduits connecting said air and ballast tanks, an airflow control mechanism for controlling the flow through said conduits, and a hot gas generator for augmenting the expulsive effort of said compressed air, which comprises the steps of:

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positioning said airflow control internally of said pressure hull;
passing said air in said conduit from said compressed air tank through said pressure hull to said airflow control;
metering said airflow and thereafter passing said metered 5
airflow back through said pressure hull to the space between said hulls and to a heat exchanger thereat;

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passing said metered airflow through said heat exchanger to said ballast tanks for expelling said ballast therefrom;
heating said air in said heat exchanger by means of said hot gas from said generator to augment the expulsive effort of said compressed air; and
discharging said hot gas externally of said submersible.

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