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[54] **PROCESS AND APPARATUS FOR PURGING GAS-CONTAINING STORAGE TANKS IN VESSELS**

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[58] **Field of Search** ..... 48/190; 23/281; 23/260, 262; 134/22 R, 21: 252/372; 220/88 B; 169/4, 12

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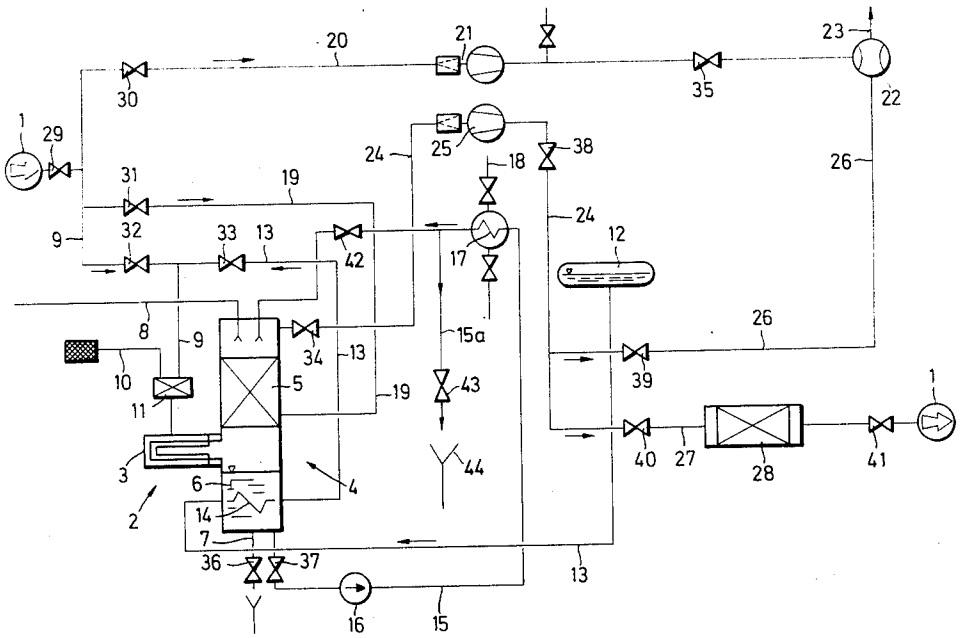
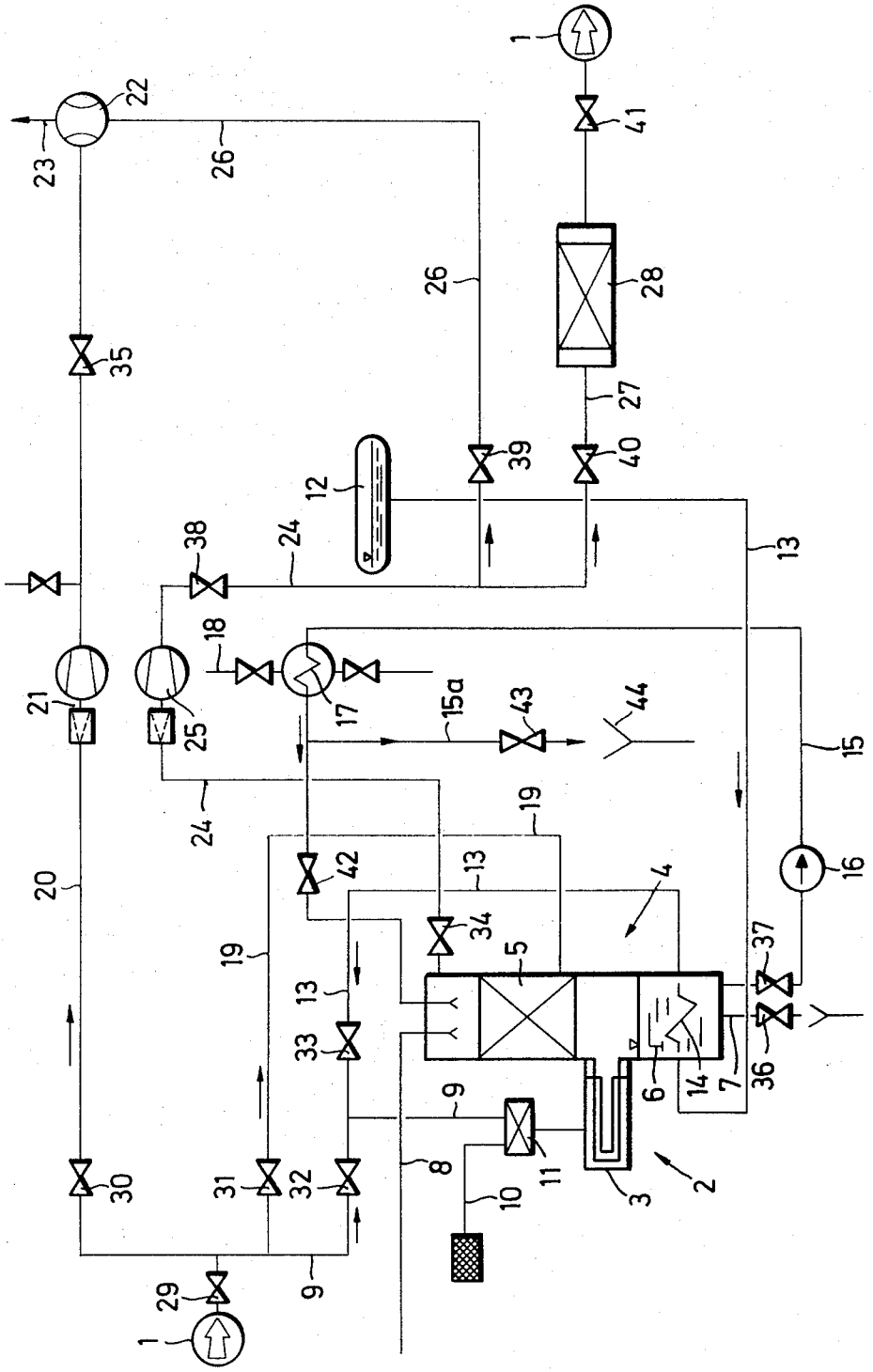
[57] **ABSTRACT**

A process and apparatus for purging gas storage tanks comprises generating a gas inert with respect to the stored gas, displacing the stored gas in the tank with part of the inert gas and admixing another part of the inert gas with the stored gas displaced from the tanks, whereby in the case of combustible stored gas explosive mixtures are avoided. The inert gas may be generated by burning a portion of the stored gas or another fuel.

17 Claims, 1 Drawing Figure

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PROCESS AND APPARATUS FOR PURGING GAS-CONTAINING STORAGE TANKS IN VESSELS

The invention relates to a process and apparatus by which storage tanks holding gases (charging gases), particularly combustible gases which are able to form explosive mixtures with a purging gas or air, are freed from residual gas or air by displacement of the charging gas by means of a gas inert with respect to the charging gas.

In order to change the charge and to free vessels, tanks and the like from residual gases, more especially from gases which form explosive mixtures or are contaminated by a following gas or air, it is known to purge or displace the residual gas which is in the vessel by introduction of a gas which is inert with respect to the residual gas and to blow the mixture off into the atmosphere. With gases which form explosive mixtures with air, it is then necessary to admix very large quantities of air, since the lower explosion limits are very low, for example about 2.8 percent by volume with C_3H_8. The mixture passes through the explosive range in a more or less wide range. The inert gas is for example supplied from storage vessels or is produced from fuel (for example fuel oil) provided for this purpose. The purging or blowing off of toxic gases or of gases which form combustible and usually also explosive mixtures with the air, represents not only a nuisance to local residents, but also a general danger. With tanker ships, these operations are frequently carried out in harbour. However, this is not desirable and often is not permitted. Consequently, for removing the gas from its tanks, the tanker often has to lay offshore or put to sea. This is troublesome and means a loss of time. If possible, it is consequently preferred to carry out the purging of gases from the tanks while the ship is on the open sea. For the purpose of changing loads, cases also arise in which it is necessary to release the residual or waste gas into the atmosphere at the shore-connection point, in order to be able to take on a new load.

It is the object of the invention to provide a process and an apparatus by which containers or tanks, more especially on board ships, can be purged of gas or air. The purging of the containers or tanks of the charging gas, more especially combustible gases, is carried out in a simple manner and in such a way that any nuisance to the surrounding areas and the danger of explosive mixtures being formed is prevented. The invention is characterised in that only a part of the gas produced by a gas generator and inert with respect to the contents of the container is used after cooling and drying for displacing the contents of the container, while the other part after cooling is admixed in sufficient quantity with the residual gas displaced from the container. With combustible charging gases, it is advantageous for a part of the gas displaced from the container to be used as combustible gas for the generation of the inert gas.

By using such a procedure, the generated inert gas is used in two different ways. The inert gas not only serves for displacing the charging gas from the containers, but a part of the generated inert gas is directly mixed with the discharged charging gas and as a result the charging gas may be brought with certainty below the danger or explosion limit and be discharged in this state into the atmosphere. As a consequence, these operations can also be carried out in harbour. It is no longer necessary for the ship to go offshore or put to sea for the purpose of changing loads. With combustible charging gases, a part of the charging gas is simultaneously used for generating inert gas and is in this way made harmless and is utilised in a very advantageous manner for changing the load.

If the combustible charging gas is already so diluted that it can no longer be brought to combustion, it is possible for another fuel kept in supply to be used for generating the inert gas. When employing liquefied gas as fuel, the heat necessary for vaporising the liquefied gas is derived indirectly from the products of combustion (smoke gases).

When ammonia is the charging gas, the danger exists that the carbon dioxide contained in the smoke gases, which amounts to about 13 – 15 percent, will react with the ammonia to form ammonium carbamate. This substance (white powder) causes clogging of the pipe conduits and fittings. When ammonia is being displaced from the tanks, therefore, only inert gases free from CO_2 can be used. The elimination of CO_2 can be effected by various processes, such as absorption in water, when low water temperatures and high gas pressures are required, or adsorption in molecular screens. Both processes involve a high expenditure for equipment and energy. According to another feature of the present invention, a CO_2-free inert gas necessary for displacing ammonia gas may be produced by the smoke gases generated by combustion being washed with water with addition of ammonia gas. The water-soluble ammonium carbamate formed by reaction of the ammonia gas with CO_2 contained in the inert gas is washed out of the gas or absorbed by the ammoniacal liquor. The CO_2-free inert gas, after being dried, is conducted into the tank for displacing ammonia.

The generator serving to produce the inert gas comprises a burner and a washing arrangement for scrubbing the gaseous products of combustion. The charging gas and/or a separate fuel are supplied to the burner. The upper end of the washing or scrubbing arrangement communicates with a mixing unit, to which the charging gas is supplied, it being possible for the gas to be mixed with the cooled inert gas and thereafter released into the atmosphere. Furthermore, a pipe leads from the upper end of the scrubbing unit to the container or tank, so that the generated gas which is inert with respect to the charging gas can be used as displacement gas. It is expedient for a drying unit to be connected in this pipe.

The invention is explained in greater detail with reference to an apparatus for freeing a container from gas or air, said apparatus being shown in the accompanying diagrammatic drawing.

Associated with one or more tanks **1** containing a charging gas is an inert gas generator **2**. The latter comprises a burner **3**, which communicates with a scrubber and condenser unit **4**. The unit is provided with a scrubbing arrangement, for example, a scrubbing tower **5** and a scrubbing water sump **6** including a discharge pipe **7**. The scrubbing water is supplied through the pipe **8**. Extending from the container **1** to the burner **3** is a pipe **9**, and air for combustion is introduced into the mixing chamber **11** through the pipe **10**. From a fuel supply arrangement **12**, a pipe **13** leads to the pipe **9** and to the burner **3**, it being possible for the pipe **13** to extend through the scrubbing water sump **6**. At this position a heat exchanger **14** or a vaporiser surface is arranged. In addition, a by-pass pipe **15** from the scrubbing water sump **6** to the upper part of the scrubbing

tower 5 is provided and a pump 16 is arranged in the pipe 15. Furthermore, a heat exchanger 17 can be arranged in this pipe 15 for transferring the heat to a medium contained in the pipe 18. Instead of having a closed circuit, it is possible by means of the pipe 15*a* to have an open circuit, which leads to a water outlet 44, suitable shut-off members 42,43 being provided. A pipe 19 leads from the pipe 9 to the lower part of the scrubbing tower 5.

Provided for releasing the charging gas into the atmosphere is a pipe 20, which leads to a compressor 21 and from thence to a mixing unit 22, from which a pipe 23 extends into the atmosphere. Connected to the upper part of the scrubbing tower 5 is a pipe 24, in which is arranged a compressor 25. This pipe 24 has a branch connection to a pipe 26, which leads to the mixing unit 22, and to a pipe 27, which communicates with a container or tank 1 holding the charging gas. A drying unit 28 is preferably arranged in the pipe 27.

Shut-off valves are indicated at 29 to 41.

For carrying out the load-changing operation for a tank 1, when the tank 1 is holding a combustible gas, the combustible gas is conveyed through the pipe 9 to the burner 3, the valves 30,31 and 33 being closed. The products of combustion generated by the burner 3 which are in the form of a gas inert with respect to the charging gas are cooled in the scrubber and cooler unit, i.e. by means of the scrubbing tower 5, scrubbing water being supplied through the pipe 8 to the scrubber tower 5. The cooled inert gas is drawn off through the pipe 24, by means of the compressor 25. Some of the inert gas then passes through the pipe 26 to the mixing unit 22, to which, after opening the valve 30, some of the charging gas is supplied through the pipe 20 and the compressor 21. From the latter, the mixture is blown off into the atmosphere through the pipe 23, the mixture being below the explosion limit. Another part of the cooled inert gas passes by way of the pipe 27 and the drying units 28 to the container 1 and serves for displacing the gas from said container. The inert gas can be generated in either a reduced pressure or a high pressure atmosphere depending upon whether the compressor 25 is installed following or preceding the combustion chamber, seen in the direction of flow. As long as the combustible charging gas still has a sufficient concentration for burning during the displacement process, the charging gas is utilised for generating the inert gas. When the fuel concentration is no longer sufficient, fuel is supplied partially or wholly from the storage unit 12 through the pipe 13 to the pipe 9, so that inert gas can be generated until the last residue of the charging gas is driven out of the container 1. The power of the burner and the capacity of the scrubbing tower in relation to the capacity of the following drying unit are preferably so adapted that it is possible for some of the displaced waste gases from the container to be so mixed with some of the inert gas which is generated in the inert gas generator but which is not dried that the gas mixture, mixed with atmospheric air, is unable to become explosive and the other part of the generated inert gas, after the drying, is conveyed into the tank for displacing the charging gas. .

If the charging gas is ammonia, some of the ammonia gas is supplied through the pipe 19 to the lower part of the scrubbing and cooling unit 4 and the scrubbing tower 5, respectively. In this way, a reaction of the carbon dioxide which is in the smoke gas with the ammonia to form ammonium carbamate results, which is washed out of the smoke gas or is absorbed by ammoniacal water in the scrubbing tower 5 as a water-soluble substance. In this way, the smoke gas is freed from CO_2 and can be conveyed into the container 1 through the pipes 24,27, after having been dried in the drying unit 28, for the purpose of displacing ammonia.

Furthermore, the inert gas generator 2 makes it possible for the displaced gas to be cleansed from water-soluble components through the pipe 19 in the scrubber of the inert gas generator if the burner is kept inoperative. After drying, this gas can be condensed in a reliquefaction plant.

If liquefied gas is used as fuel, this has to be transformed into the gaseous state before being burned in the gas burner of the inert gas generator 2. Serving for this purpose is the the heat exchanger or evaporator 14 located in the scrubbing water sump 6. This evaporator 14 is heated by the heated cooling water of the scrubbing tower 5 serving to heat the fuel which is flowing in the pipe 13 and which is thereby converted into the gaseous state.

The by-pass pipe 15 permits the heat of combustion in the generation of inert gas to be utilized. For this purpose, the heated cooling water discharging from the scrubbing unit 5 can be drawn off by means of the pump 16 and conveyed through a heat exchanger 17, in which the heat is given off to another medium in the pipe 18. Consequently, the inert gas generator can be used as heating source for an open or closed hot water circuit, for example, for heating up the charging gas or the like.

The gases from the charging tank 1 can be subjected to all kinds of different processes by means of the inert gas generator 2, for example, they can either be washed or burned to form inert gas, whereby a safe removal from the tank takes place. At the same time, it is possible to produce a mixture of inert gas and charging gas, which is harmless and can thus be discharged into the atmosphere. The portion of the inert gas which is in the pipe 24 and which flows to the pipe 27 is preferably in the ratio of about 50 : 50. The ratio can also be varied within wide limits by means of the valves 39 and 40, if this is necessary.

I claim:

1. A process for purging a storage tank, such as a tank on a tanker ship, of stored gas comprising:
   a. burning fuel to generate a continuous stream of gas inert with respect to said stored gas,
   b. dividing said continuous gas stream into first and second inert gas streams,
   c. directing said first inert gas stream into a storage tank to displace said stored gas from said tank,
   d. admixing said second inert gas stream with said displaced gas following removal from said tank to further dilute said displaced gas, and
   e. discharging said dilute displaced gas into the atmosphere.

2. A process according to claim 1 wherein said stored gas is combustible, a part of said stored gas being utilized as said fuel and burned to generate said inert gas.

3. A process according to claim 1 wherein said fuel is liquefied gas, said process comprising the further step of transferring a sufficient amount of the heat from the hot inert gas product of said burning to vaporize said liquefied gas fuel prior to burning.

4. A process according to claim 2 wherein said stored gas is liquefied gas, said process comprising the further step of transferring a sufficient amount of the heat from the hot inert gas product of said burning to vaporize said part of said stored gas prior to burning.

5. A process according to claim 1 wherein said stored gas is ammonia gas, said process comprising the further step of adding a portion of said ammonia gas to the inert gas product of said burning to react with CO_2 in said inert gas product forming ammonium carbamate precipitate, whereby CO_2 is removed from said inert gas before contacting said stored gas.

6. A process according to claim 1 comprising the further steps of cooling the inert gas with a liquid cooling medium and utilizing the heat transferred to said cooling medium to warm said fuel before being burned.

7. A process according to claim 3 wherein said heat transfer step comprises passing said hot inert gas through a scrubbing liquid to cool said inert gas and subsequently passing said scrubbing liquid and liquefied gas fuel through heat transfer means to warm and vaporize said liquefied gas fuel.

8. A process according to claim 4 wherein said heat transfer step comprises passing said hot inert gas through a scrubbing liquid to cool said inert gas and subsequently passing said scrubbing liquid and said part of said stored liquefied gas through heat transfer means to warm and vaporize said stored liquefied gas before being burned.

9. Apparatus for purging a storage tank, such as a tank on a tanker ship, of stored gas comprising:

a. burner means for burning a fuel to produce a gas inert with respect to said stored gas,

b. scrubber means for receiving, cooling and washing said inert gas,

c. conduit means (**20**) for directing stored gas from said tank to a location for discharge of said stored gas,

d. further conduit means (**9—9**; **13–9**) for conducting fuel from a fuel supply to said burner means,

e. further conduit means for directing said inert gas from said burner means to said scrubber means,

f. further conduit means (**24, 26, 27**) for dividing the flow of scrubbed inert gas from said scrubber means into first (**27**) and second (**26**) parts and directing said first part of said inert gas into said tank to dilute and purge stored gas in said tank and directing said second part of said inert gas to said conduit means (**20**) for further diluting said storage gas from said tank before reaching said location for discharge, and

g. valve means to regulate flow through said conduit means,

h. whereby stored gas may be diluted prior to discharge into the atmosphere and storage tanks may be safely purged.

10. Apparatus according to claim 9 wherein said further conduit means (**13-9**) extends from a source of fuel to said burner means for conducting said fuel to said burner means, said apparatus further comprising further conduit means (**19**) connecting the outlet of said tank with said scrubber means whereby any component of said inert gas capable of reacting with said stored gas may be removed by feeding stored gas from the tank into said scrubber means to react said component with said stored gas before said inert gas flows through said further conduit means (**24, 26, 27**) and contacts said stored gas in said conduit means (**20**) and in said tank.

11. Apparatus according to claim 9 wherein said further conduit means (**9—9**) extends from said tank to said burner means for conducting combustible stored gas to said burner means.

12. Apparatus according to claim 9 wherein said further conduit means (**13–9**) extends from a source of fuel to said burner means for conducting said fuel to said burner means.

13. Apparatus according to claim 10 wherein said scrubber means comprises a scrubbing tower, means for feeding scrubbing water downwardly through said inert gas in said tower to scrub and cool said inert gas, and further conduit means (**15**) for recycling said scrubbing water.

14. Apparatus according to claim 13 wherein said further conduit means (**15**) includes heat exchange means to cool said recycling scrubbing water.

15. Apparatus according to claim 13 wherein said further conduit means (**13–9**) extends from a liquid fuel supply to said burner means, said further conduit means (**13–9**) including heat exchange means in said scrubbing tower whereby the liquid fuel may be vaporized by heated scrubbing water.

16. Apparatus according to claim 10 further comprising drying means in said first part of said further conduit means (**24, 26, 27**) to dry said inert gas from said scrubber means before being fed to said tank.

17. Apparatus for purging a stored tank, such as a tank on a tanker ship, of stored gas comprising:

a. burner means for burning a fuel to produce a gas inert with respect to said stored gas, ,

b. scrubber means for receiving, cooling, and washing said inert gas,

c. conduit means (**20**) for directing stored gas from said tank to a location for discharge of said stored gas,

d. further conduit means (**9—9**) for directing stored gas from said tank to said burner means,

e. further conduit means for directing said inert gas from said burner means to said scrubber means,

f. further conduit means (**24, 26, 27**) for dividing the flow of scrubbed inert gas from said scrubbing means into first (**27**) and second (**26**) parts and directing said first part of said inert gas into said tank to dilute and purge stored gas in said tank and directing said second part of said inert gas to said conduit means (**20**) for further diluting said stored gas from said tank before reaching said location for discharge, and

g. valve means to regulate flow through said conduit means,

h. whereby stored gas may be diluted prior to discharge into the atmosphere and storage tanks may be safely purged.

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