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SAMPLING ARRANGEMENT FOR LIQUID GASES

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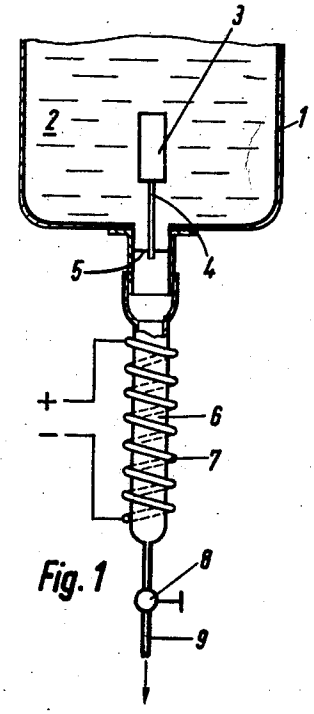

Fig. 1

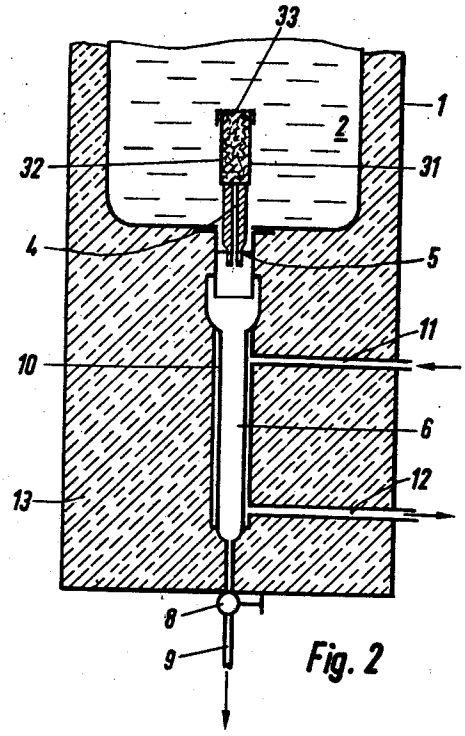

Fig. 2

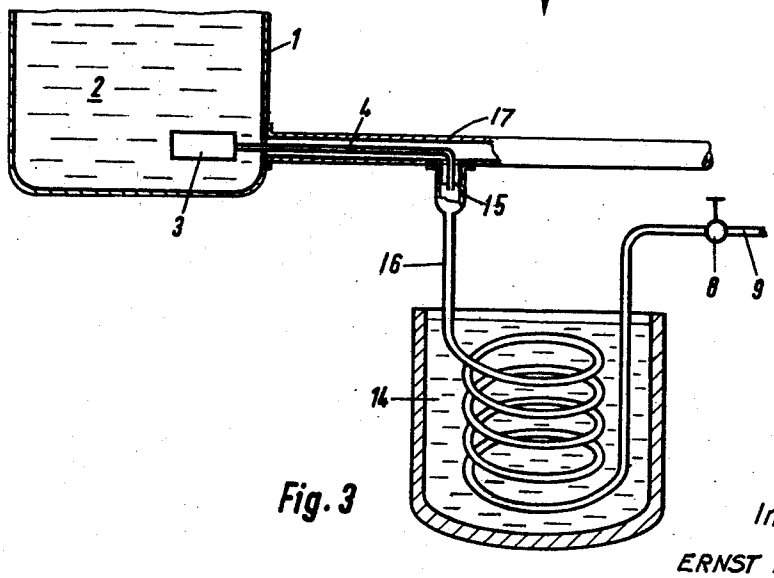

Fig. 3

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SAMPLING ARRANGEMENT FOR LIQUID GASES

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The present invention relates to an arrangement for sampling liquefied gases in order to determine the composition thereof by analysis, more particularly, to such an arrangement wherein the tapped liquid gas is evaporated into a gas having the same composition as the body of liquid gas so as to obtain accurate analysis results.

In the separation of air and gases, it is essential to automatically control the composition of the gaseous and liquid mixtures flowing throughout the separation installation. It is difficult, however, to automatically and accurately sample a liquid gas, such as liquid oxygen tapped from the main condenser of an air separation installation, when it is desired to control the content of traces of substances in the liquid oxygen, such as for example, hydrocarbons.

It is characteristic of many mixtures of oxygen and a hydrocarbon that in the initial evaporation thereof the resulting gaseous phase contains virtually no hydrocarbons because the hydrocarbons accumulate in the last remaining residue of the liquid mixture. In order that a sampling of a liquid mixture be accurate, it is a requirement that nothing be lost either from the initially produced gaseous phase which is usually free of hydrocarbons or from the last portion of the liquid to be evaporated. Various sampling arrangements which have been previously known, do not satisfactorily meet this requirement.

The conventional sampling arrangement usually comprises a tube from which a liquid sample is drawn from the container for the liquid with the sample then being passed through a throttling valve into an evaporator. This arrangement does not operate satisfactorily because an uncontrollable evaporation of the liquid occurs in the tubing before the liquid has reached the throttling valve. As a result, the gas and liquid flow alternatingly and intermittently through the throttling valve into the evaporator. The composition of this sample, as ultimately received by the analysis apparatus, is therefore not identical with the composition of the liquid contained in the storage tank from which the so-called sample was taken.

It has been also proposed to alternatingly discharge samples, taken from a tank, into two evaporators wherein the liquid gases are evaporated and then introduced into the analyzer. This arrangement has the disadvantage, however, that a continuous sampling is not possible but only samples taken at intermittent periods of time. In addition, the evaporator into which a liquid gas sample is to be introduced, must first be cooled and then heated during the evaporation process. This means that the evaporator must be cooled and heated for predetermined periods. Further, the vapors last formed during the evaporation process, contain a considerable portion of those constituents, such as hydrocarbons, which are of interest for the analysis. A special method step is therefore necessary to scavenge these vapors from the sampling evaporator. There must then be provided a complicated assembly of automatic locking devices and scavenging tubes in order to conduct an accurate analysis of the sample.

It is therefore the principal object of the present invention to provide a novel and improved arrangement for sampling a liquid gas so that the analyzed samples have the same composition as the body of liquid gas from which they were taken.

The sampling arrangement of the present invention essentially comprises a filter chamber positioned within the body of liquid gas and having a capillary tube extending from the filter chamber through the body of liquid gas so that one end of the tube projects outwardly of the wall of the tank for a short distance. The projecting end of the tube is connected to one end of a tubular evaporator having a relatively large cross-section so as to present relatively little resistance to the flow of gases therethrough. A heating arrangement is mounted on the evaporator to heat the contents thereof so as to evaporate them. The lower end of the evaporator is provided with a control valve and is connected to a gas analyzer, such as a gas chromatograph.

In the operation of this arrangement, a thin stream of liquid gas flows through the filter chamber and the capillary tube into the evaporator. The thin stream of liquid is completely evaporated within the evaporator and then flowed to a gas analyzer for analysis.

The analysis can be continuous since a sample stream may be continuously drawn from the body of the liquid gas.

Other objects and advantages of the present invention will be apparent upon reference to the accompanying description when taken in conjunction with the following drawings wherein:

FIGURE 1 is a schematic elevational view of a sampling arrangement according to the present invention;

FIGURE 2 is a schematic elevational view of a modification of this arrangement; and

FIGURE 3 is a schematic elevational view of a further modification of the sampling arrangement.

A specific embodiment and several modifications of the present invention will next be described in detail with reference to the drawings wherein like reference symbols indicate the same parts throughout the various views.

As seen in FIGURE 1, there is illustrated a tank **1** containing liquid oxygen **2**. A filtering chamber **3** is positioned within the body of liquid oxygen. The filtering chamber may comprise either a porous ceramic or metallic mass whose pores have such a size to pass solid particles which are smaller than the diameter of a capillary tube **4** which has one end welded to the bottom of the filtering chamber **3**. The filtering chamber may also comprise a fibrous glass mass enclosed within a container and covered with a screen or sieve.

The capillary tube **4** is of metal and has an inside diameter ranging from several tenths of millimeters to about 2 mm. Virtually the entire length of the capillary tube **4**, which may range from a few centimeters to several meters, is positioned in the body of the liquid oxygen. The length of the capillary tube **4** will depend upon the position of the filter chamber **3** with respect to the wall of the tank **1**.

Where the liquid sample is tapped out of the interior of the tank **1** and the length of the capillary tube within the body of the liquid gas is considerable, the flow resistance of the capillary tube is then adapted to the pressure gradient existing between the interior of the storage tank and the vaporizer connected to the outer end of the capillary tube. Under normal conditions the diameter of the capillary tube is somewhat greater than when the capillary tube is but a few centimeters long.

In place of the capillary tube one can employ a tube or pipe having a considerably larger diameter but having a reduced diameter portion at one point so as to form a nozzle or diaphragm opening within the tube.

One end of the capillary tube passes through the wall of the tank at **5** and opens into a tubular evaporator **6** which is directly connected to the wall of the tank **1**. An electric heating coil **7** is mounted on the exterior wall of the evaporator **6**.

The lower end of the evaporator has connected thereto a tubular portion 9 in which is mounted a control valve 8 and which leads to the sampling analyzer. The gas analyzer may comprise, for example, a gas chromatograph.

In order to operate the sampling arrangement as described above, the control valve 8 is opened and a fine stream of liquid passes through the filter chamber 3 and capillary tube 4 into the evaporator 6 wherein it is continuously and totally evaporated into a gaseous mixture. This gaseous mixture continuously flows through conduit 9 to the gas analyzer and a composition of this mixture is identical to that of the liquid contained in the tank 1.

The liquid sample admitted through the filtering chamber 3 will not evaporate in the capillary tube 4 since the outer wall of the tube 4 is cooled by the body of liquid within the tank 1 from which the sample has been drawn.

The speed of the sample flowing through the filter chamber and capillary tube into the evaporator and the speed at which the gaseous mixture is discharged from the evaporator, are controlled by the valve 8 so that the pressure within the evaporator 6 is at no time greater than the pressure in the storage tank 1. Because of this pressure relationship, the gases within the evaporator cannot flow back from the evaporator through the capillary tube into the tank 1. The flow of the liquid is then always directed from the tank 1 toward the valve 8. As a result, the flow of the gas sample admitted to the analyzer is uniform, homogeneous in its composition and identical to the composition of the liquid gas contained in the tank 1.

In the modification of FIGURE 2, the filter chamber comprises a casing or container 31 which is filled with a fibrous glass mass 32. One end of the container is closed with a wire screen 33 and the other end is welded to the capillary tube 4.

The evaporator 6 is surrounded by an outer casing 10 so as to form a jacket around the evaporator. Tubes 11 and 12 form the inlet and outlet respectively for a warm, dry gaseous medium, such as air, which heats the evaporator in order to evaporate the stream of liquid flowing therethrough. The evaporator and the tubular passages 11 and 12 are embedded into an insulating layer 13 which surrounds the storage tank 1.

Thus, while the evaporator of FIGURE 2 is heated by warm gases, the operation of this modified sampling arrangement is the same as that described for the embodiment of FIGURE 1.

In the modification of FIGURE 3, the capillary tube 4 extends from one end of the filter chamber 3 to pass through a conduit 17 for the liquid gases and opens through a wall 15 of the conduit 17 to form a spiral evaporator 16 positioned in a heated water bath 14. The other end of the evaporator has a control valve 8 therein and the portion indicated at 9 is connected to a gas analyzer.

The several elements disclosed in the embodiment and modifications thereof may also be combined in different ways according to the operating circumstances. For example, the evaporator may be heated partially by warm gases as shown in FIGURE 2 and partially with warm water as shown in FIGURE 3.

In the utilization of the present invention for controlling a gas separating installation, such as an installation for separating air, the sampling arrangements as described above may be mounted onto the tanks whose contents are to be continuously controlled. Such tanks or containers may comprise the sump of a rectification column, a separator or other containers as may be found in such an installation.

The gaseous streams formed from the tapped liquids are flowed together with other gaseous samples through control valves to a gas chromatograph which automatically and continuously records on its recording strip the various reactions and conditions in the gas separating installations so as to enable the processes to be most effectively controlled.

Thus it can be seen that the present invention provides a sampling arrangement wherein a liquid sample may be continuously drawn from a body of a liquid gas and then completely evaporated into a gaseous mixture whose composition is identical with the composition of the liquid gas in the container. The resulting gaseous mixture can then be analyzed in a conventional and well-known manner to have a continuous indication of the composition of the liquid gas.

It will be understood that this invention is susceptible to further modification and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

What is claimed is:

1. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, said pipe having a reduced diameter portion therein, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, means on said evaporator for heating the same to evaporate the liquid gas therein entering through said pipe, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

2. An arrangement as claimed in claim 1 wherein said filter chamber comprises a porous metallic body.

3. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, said pipe having a reduced diameter portion therein, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, a casing surrounding said evaporator and forming a jacket therearound with inlet and outlet means leading to said jacket for the circulation of a gaseous heating medium around said evaporator, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

4. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, said pipe having a reduced diameter portion therein, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, a heated body of water surrounding said evaporator to heat the same, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

5. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, said pipe having a reduced diameter portion therein, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, an electrical heating coil mounted

on said evaporator to heat the same, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

6. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, there being a nozzle in that portion of said pipe within the body of liquid gas, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, means on said evaporator for heating the same to evaporate the liquid gas therein entering through said pipe, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

7. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, there being a diaphragm opening in that portion of said pipe within the body of liquid gas, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, means on said evaporator for heating the same to evaporate the liquid gas therein entering through said pipe, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

8. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, at least that portion of the pipe within said body of liquid gas being a capillary tube, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, means on said evaporator for heating the same to evaporate the liquid gas therein entering through said pipe, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

9. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a tank containing a liquid gas therein, a heat insulating layer surrounding said tank, a filter chamber positioned within the liquid gas in said tank, a pipe extending from said filter chamber through said body of liquid gas with one end thereof projecting a short distance outwardly through a wall of said tank, said pipe having a reduced diameter portion in the length of the pipe passing through the liquid gas, a tubular evaporator having low-flow resistance with the upper end thereof receiving the projecting end of said pipe, a portion of said evaporator being positioned in said tank insulating layer, means on said evaporator for heating the same to evaporate the liquid gas therein entering through said pipe, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

10. An arrangement for the continuous sampling of a liquid gas tapped from a tank and evaporating the tapped liquid into a gas for analysis thereof, and comprising a filter chamber positioned within a body of a liquid gas contained in a tank, a pipe extending from said filter chamber through said body of liquid gas with one end of said pipe projecting a short distance outwardly of a wall of the tank, said pipe having a reduced diameter portion therein, a tubular evaporator having a low-flow resistance with the upper end thereof receiving the projecting end of said pipe, a body of heat insulating material surrounding said evaporator, means in said evaporator for heating the same to evaporate the liquid gas therein entering through said pipe, the lower end of said evaporator having a control valve therein and connected to a gas analyzer.

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