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STEAM PURGE INDICATOR METHOD AND APPARATUS

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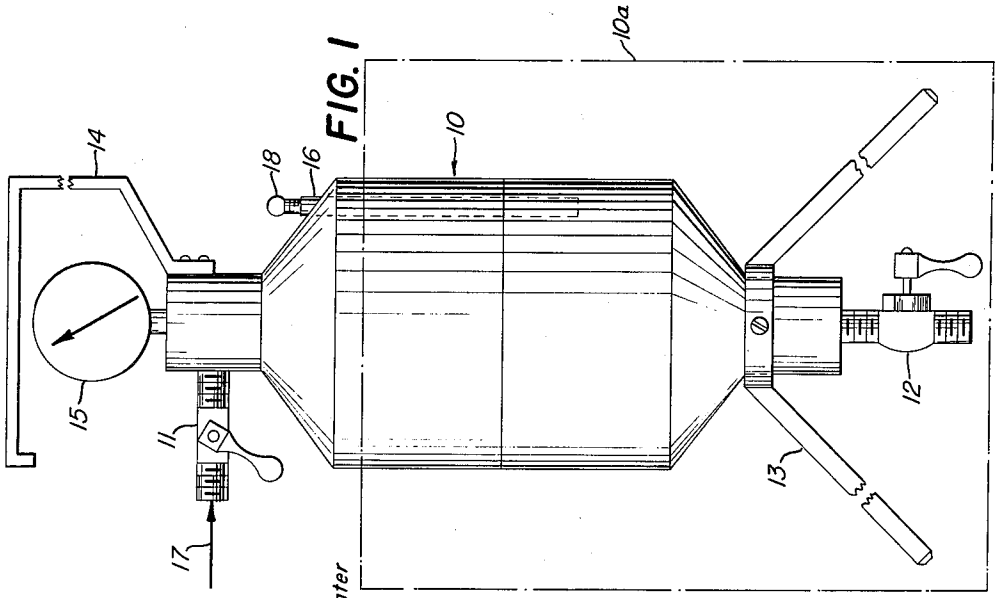


FIG. 1

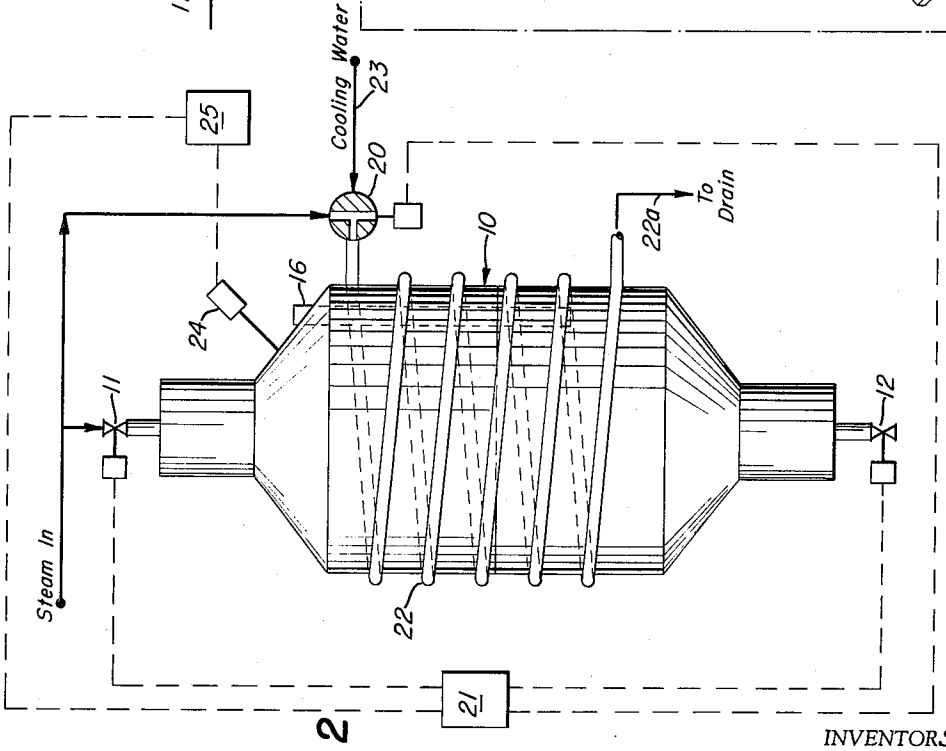


FIG. 2

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STEAM PURGE INDICATOR METHOD AND APPARATUS

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This invention relates to method and apparatus for determining a variable composition comprising a mixture of readily condensable gas and relatively non-condensable gas. In a more specific sense, the invention relates to a system for indicating the end point of steam purging operations.

In petroleum refining, it is often necessary to remove non-condensable combustible and/or combustion-supporting gases from a system before introducing other substances into the associated apparatus. If such gases remain in the system they may cause corrosion, may poison catalyst, or may constitute a fire or explosion hazard during a subsequent operation within the system.

Steam purging of process vessels and the like is one method commonly employed to purge such gases below the level at which combustion resulting in explosion or detonation could occur. Normally, the practice has been to discontinue steam purging upon a show of steam at the exhaust, the assumption being made that steam has completely displaced the non-condensables from the system. However, this method does not give a reliable indication of the removal of the combustible or combustion-supporting gases because such gases are not necessarily displaced first by the flow of steam from the exhaust end of the system. Thus the gases are often exhausted in partial admixture with the purging steam and the mere show of steam, therefore, does not indicate that the system has been completely purged of the non-condensable gases.

We have made tests of steam exhausting into the atmosphere and based on visual observations and photographs, there is little difference in the appearance of pure steam on the one hand and steam-air mixtures on the other, unless the air content of the steam exceeds 50%. Such an indication is of little value.

Many systems have heretofore been proposed for measuring the proportion of condensables in a steam purging operation for indicating the safe end point. One such system measures change in volume at constant pressure. Apparatus conventionally used in such system consists essentially of a glass bulb enclosed in a sheet metal case and insulated against heat loss, the upper part of the enclosed bulb being graduated.

A stop-cock is provided at the upper end of the glass bulb and a two-way stop-cock at the lower end of the bulb permits connection at the bottom either to a water-filled leveling bottle or to the atmosphere. Air is displaced from the bulb by water from the leveling bottle. The upper stop-cock is then connected to a sample point on the steam purged vent pipe, preferably with heavy-walled rubber tubing.

The upper stop-cock is opened to displace the water from the bulb into the leveling bottle and as the water level reaches the lower two-way stop-cock, the latter is turned to permit the sample of purged gas to flow freely through the apparatus for not less than about five minutes. A sample is then trapped within the glass bulb by operating both upper and lower stop-cocks. Water from the leveling bottle enters the indicator bulb to replace the condensed vapor. The non-condensable gas volume remaining within the bulb is read from the calibrated scale on the bulb. However, before making the reading, the water levels within the bulb and leveling

bottle are made equal by adjusting the latter, thereby assuring atmospheric pressure in the bulb. It will be apparent that such an apparatus is fragile and that the system is complicated so as to require considerable technical skill and judgment in its operation.

An important object of the invention accordingly is to provide a system which avoids all of the complications and difficulties inherent in the volume measuring kind of apparatus. A more specific object is to provide a system wherein it is not necessary to measure the volume of the non-condensables directly. A further object is to provide a simple and relatively inexpensive portable apparatus which is both durable and accurate and which can be used to make the determinations of non-condensables by simply noting the pressure within a sample cylinder before and after condensation of a confined volume of exhaust steam purge effluent.

It is also a principal object of this invention to provide an apparatus for the determination of the amount of readily condensable gas or the percentage of non-condensables present in a mixture. A further object of the invention is to provide a method and apparatus for determining the end point at which all non-condensable gases have been removed from a system in a steam purging operation. A more specific object of the invention is to provide a steam purge indicator of simplified construction and operation and wherein a simple pressure measurement will provide an indication of the non-condensables in the system being purged.

Briefly, according to the invention, a sample of vent steam is passed through a chamber, the chamber being provided with inlet and outlet valves at opposite ends thereof. The temperature within the chamber is measured, and when equilibrium conditions are indicated by a constant temperature reading, the inlet and outlet valves on the sampling chamber are quickly closed, in that order, to trap a sample of purge gases within the chamber at atmospheric pressure.

The chamber containing the trapped sample is cooled rapidly to a preselected temperature, preferably about 100° F., by, for example, immersing in water. The cooling reduces the pressure within the chamber by condensing the condensable water vapor. The pressure indicated by a gauge communicating with the chamber is a measure of non-condensables in the vent gas.

Since the vapor pressure of water at 100° F. is about 2 inches Hg, 100% steam in the sample chamber will produce a vacuum numerically equal to 2 inches Hg less than the total barometric pressure. Thus, for example, if the local barometric pressure is equal to 30 inches Hg, the vacuum gauge reading will be 28 inches Hg. If less vacuum is observed, for example, 26 inches Hg, this indicates the presence of non-condensables. Accordingly, the percent non-condensables can be indicated as a function of the vacuum gauge reading and a limiting vacuum reading can be specified beyond which the purge may be considered satisfactory. If the actual percentage of non-condensables present need be known, it may be calculated from data obtained with the instrument by methods well known to those skilled in the art.

The device may be calibrated quickly in the field by connecting to a steam line. This will indicate the gauge reading for 100% steam thereby eliminating the need for determining the local barometric pressure. This will also serve as a leak test for the device.

In addition to simplifying the calculation and eliminating the need for referring to a barometer, the initial measurement on steam, free from non-condensables, provides a leak test of the apparatus wherein tightness is shown by maintainence of the low pressure reading. Further, this check has the effect of measuring the baro-

metric pressure with the instrument gauge thereby compensating for minor inaccuracies in the gauge.

Further advantages and details of the construction of our apparatus will be described by reference to the accompanying drawings wherein:

FIGURE 1 is a schematic elevation illustrating the invention; and

FIGURE 2 illustrates an automatic recording embodiment of the invention.

Referring to FIGURE 1, the sample cylinder **10** is provided with an upper inlet valve **11** and a lower outlet valve **12**, each communicating with the interior of the cylinder **10**. The cylinder **10** is of a shape which allows free passage of purging gases throughout its interior without any holdup by occlusion or otherwise. The lower end of the cylinder **10** is provided with a tripod support **13**. The upper end of the apparatus is provided with a carrying handle **14**.

The pressure gauge **15** is in communication with the cylinder **10** below the inlet valve **11** and a thermometer well **16** projects through a wall of the cylinder **10**. The outlet valve **12** is adjusted to drain fluids from the cylinder **10** and to maintain atmospheric pressure therein during the sampling.

When it is desired to make a test, exhaust steam from a purging operation is charged by line **17** to the cylinder **10** through the inlet valve **11** while the outlet valve **12** is maintained in an open position. The condensation temperature of the exhaust steam, i.e. the point at which no further reduction in pressure is observed, is measured in well **16**. The purge gases are permitted to flow through the device until the temperature as indicated by the thermometer **18** is constant. The inlet valve **11** is first closed and then the outlet valve **12** is also closed thereby trapping a uniform sample of exhaust steam at atmospheric pressure.

The cylinder **10** is cooled by natural convection or the cooling rate may be accelerated by spraying with cooling fluid or immersing the cylinder **10** in such a bath **10***a* as schemactially shown in FIGURE 1.

If low ambient temperatures require excessive time to obtain the equilibrium condensation temperature within cylinder **10**, an insulated container (not shown) can be provided into which cylinder **10** can be inserted during the flow of the sample into the device. After equilibrium condensation temperature is reached and valves **11** and **12** have been closed, the cylinder **10** is removed from the insulated container and cooled as described. If desired, the tripod support **13** may be modified so as to support the insulated container.

When the measurement of non-condensables in steam is desired for the control of a continuous process, for example, or for other reasons, remote indication and/or continuous recording of such measurements may be desirable. Such a device is illustrated in FIGURE 2 and can be made completely automatic.

In the embodiment of FIGURE 2, the steam-air mixture is admitted through valve **11** and exhausted at the bottom of the chamber **10** through valve **12**. A portion of the same steam is admitted to coil **22** surrounding the chamber **10**, and connected to the chamber **10** through two-way valve **20**.

Cycle timer **21** controls valves **11**, **12** and **20** in such a manner that flow into the chamber **10** and coil **22** continues for a preselected time sufficient to bring the chamber **10** to equilibrium temperature. The cycle timer **21** then closes valves **11** and **12** to trap the sample within the chamber **10** and at the same time actuates two-way valve **20** to flow cooling water from line **23** through the coil **22** in place of the steam mixture.

Absolute pressure transmitter **24**, coupled with receiver **25**, which may be indicating or recording or both, provides continuous record of the pressure in chamber **10**. As described with respect to FIGURE 1, the pressure within the chamber **10** after cooling to the preselected temperature is a measure of the non-condensables in the stream introduced to the test chamber **10**.

If desired, receiver **25** can be made a recorder-controller which will sense the equilibrium "hot" condition of the chamber **10** and actuate the cycle timer **21** so that it may follow through the cycle described above.

The system in accordance with the invention is particularly advantageous when used to determine the safe oxygen content of steam-air mixtures used in operations such as the regeneration of desulfurization reactors during reforming operations or for determining the safe end point when purging combustion-supporting gases from process equipment, generally. However, the devices may be readily adapted to a control operation involving the determination of non-condensables and condensables in a given system. It is also contemplated that a non-condensable purge gas may be used to purge a condensable gas or vapor from a system in which case the end point in the purging operation is determined by the presence of 100% non-condensables in the exhaust from the system being purged.

Although the invention has been described in terms of a preferred embodiment which has been set forth in some detail, it should be understood it is by way of illustration only and that the invention is not necessarily limited thereto. Alternative embodiments of the invention will become apparent to those skilled in the art in view of the accompanying description and accordingly, modifications in the invention are contemplated without departing from the spirit thereof.

What we claim is:

1. A method for measuring and indicating the presence of non-condensable gases in admixture with a condensable gaseous medium which comprises trapping a selected volume of said admixture under atmospheric pressure, cooling said trapped volume to a preselected temperature well below the condensation temperature of the said gaseous medium, and indicating the pressure of said volume at said preselected temperature as a measure of the trapped non-condensable gases.

2. The method of claim 1 wherein the said condensable gaseous medium is steam and the preselected temperature is about 100° F.

3. A method for quantitatively indicating the presence of non-condensable gases in admixture with a condensable gaseous medium which comprises trapping a sample of said admixture within a container under atmospheric pressure, cooling said container to a pre-determined temperature well below the condensation temperature of the said gaseous medium, and indicating the pressure within said container as a measure of the non-condensable gases present in the admixture.

4. A device for indicating the presence of non-condensable gases in an admixture with steam which comprises a sampling vessel for said admixture, temperature indicator means on said vessel, pressure indicator means for said vessel, an inlet valve positioned on and communicating within said vessel, an outlet valve positioned on the lower end of said vessel, a cycle timer valve-control device sequentially closing said inlet valve and said outlet valve, respectively, and fluid cooling bath means for immersing said vessel.

5. A device for indicating the end point of steam purging operations which comprises a portable vessel, means for indicating the temperature within said vessel, inlet valve means on one end of said vessel, outlet valve means on the other end of said vessel, a cooling bath means adapted to receive said vessel, handle means on said vessel for manipulating said vessel so as to submerge it within said cooling bath, means for indicating pressure in said vessel, and cycle timer means for sequentially closing said inlet and outlet valve means.

6. A device for indicating the presence of non-condensable gases in a condensable gaseous medium which comprises a portable container, means for indicating the pres-

sure within said container, inlet valve means on said container, outlet valve means on said container, means about said container for controlling the temperature thereof, and means for automatically controlling said inlet valve means and said outlet valve means and wherein said means for controlling the temperature of said container includes coil means surrounding said container and through which heat exchange media flow.

7. A device for indicating the presence of non-condensable gases in a condensable gaseous medium which comprises a portable container, means for indicating the pressure within said container, inlet valve means on said container, outlet valve means on said container, means about said container for controlling the temperature thereof, and wherein said means for indicating the pressure comprises an absolute pressure transmitter and a pressure recorder-controller, and a cycle timer means for controlling said inlet and outlet valve means, said cycle timer means being actuated by said recorder-controller.

8. An automatic steam purge indicator apparatus comprising a sample trapping vessel, valved inlet means on said vessel, valved outlet means on said vessel, pressure sensitive means connected to said vessel, means for heating said vessel, means for cooling said vessel, and cycle timer means actuated by said pressure sensitive means to control said inlet and outlet valves and said heating and cooling means.

9. The apparatus of claim 8 wherein said cycle timer is adapted to close said outlet valve after closing said inlet valve.

10. The apparatus of claim 8 wherein said heating means comprises coil means about said vessel adapted to receive a portion of the steam being sampled, and wherein said means for cooling said vessel includes a source of cooling fluid which is flowed through said coil means.

11. A device for indicating the presence of non-condensable gases in a condensable gaseous medium which

comprises a portable container, means for indicating the pressure within said container, inlet valve means on said container, outlet valve means on said container, means about said container for controlling the temperature thereof, and wherein said means for indicating the pressure comprises an absolute pressure transmitter communicating with said container and a pressure receiver remote therefrom, and a cycle timer means for controlling said inlet and outlet valve means, said pressure receiver being a recorder-controller arranged to actuate the cycle timer means.

12. An apparatus for measuring and indicating the presence of noncondensable gases in admixture with a condensable gaseous medium which comprises means for trapping a selected volume of said admixture under atmospheric pressure, means for cooling said trapped volume to a preselected temperature well below the condensation temperature of the said gaseous medium, and means for indicating the pressure of said volume at said preselected temperature as a measure of the trapped noncondensable gases.

13. An apparatus for quantitatively indicating the presence of noncondensable gases in admixture with a condensable gaseous medium which comprises means for trapping a sample of said admixture within a container under atmospheric pressure, means for cooling said container to a predetermined temperature well below the condensation temperature of the said gaseous medium, and means for indicating the pressure within said container as a measure of the noncondensable gases present in the admixture.

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