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AIR DILUTION ATTACHMENT FOR EXPLOSIVE-GAS ANALYZERS

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Fig. 1

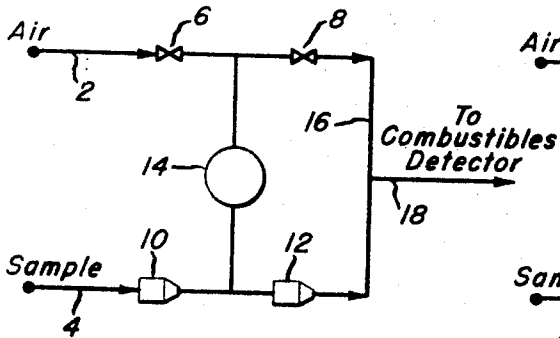


Fig. 2

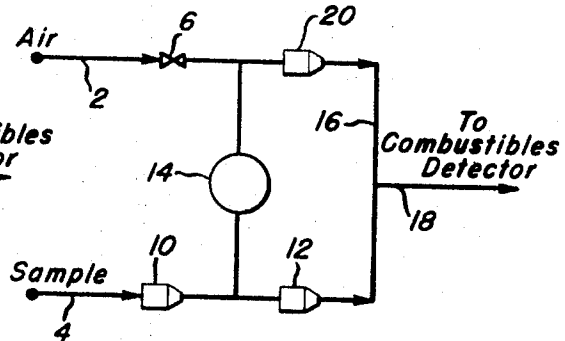
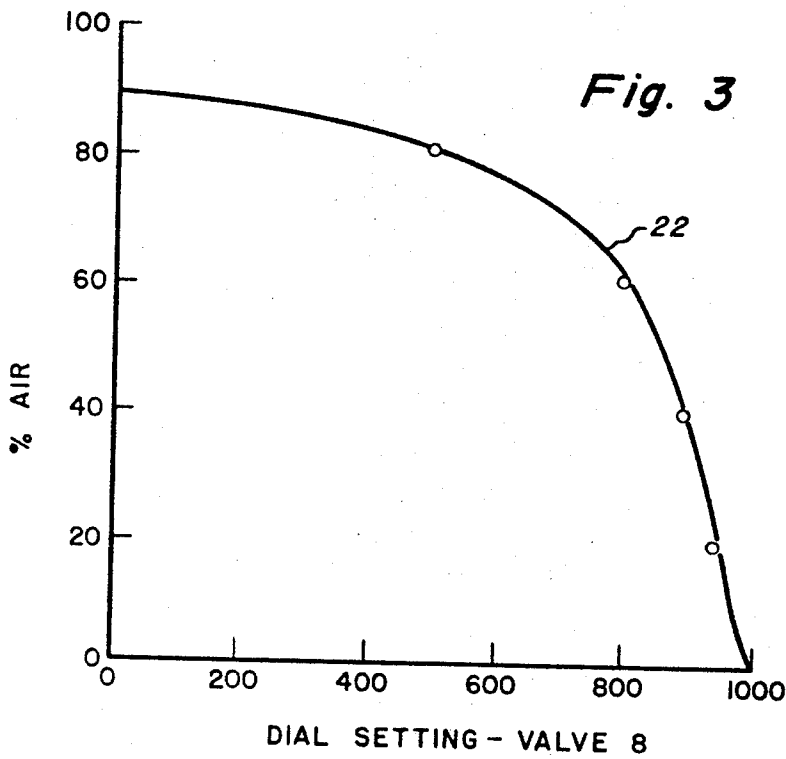


Fig. 3

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5 Claims

ABSTRACT OF THE DISCLOSURE

This invention concerns the combination of a pneumatic bridge and a combustible detector. The pneumatic bridge, which is provided with a pressure differential detector that indicates a pressure imbalance in the bridge, mixes a gaseous sample and air together at a predetermined ratio. When the detector indicates an imbalanced condition, an adjustable valve in the bridge provides means for regulating flow through the bridge so that the mix ratio remains constant.

This invention relates to explosive-gas analyzers and more particularly to an improved air dilution system for use with explosive-gas analyzers.

The explosive-gas analyzer or combustible detector as it is also known is an instrument of vital importance in many chemical industries because of the danger of explosive-gas mixtures developing in tanks and rooms that contain volatile chemicals. In the petroleum industry, for example, refinery units are often purged of hydrocarbon gases with an inert gas such as nitrogen before the units are opened to the atmosphere. The purging must be continued until the hydrocarbon concentration is low enough that when the vessel is opened to the atmosphere no flammable mixtures will be obtained. In order to follow the progress of the purging operation, continuous measurement of hydrocarbon is needed. The accurate measurement of hydrocarbons in inert gas is difficult, however, with present instruments since the usual analyzer will not function in the absence of oxygen. Current practice has been to purge for a prescribed time which past experience or past laboratory tests has shown to produce hydrocarbon-free vessels. While such a technique is generally satisfactory, there are two drawbacks. One is that the particular system may be different from its condition when the previously determined "safe" purge time was determined and the other is that an operation of this type is wasteful of both inert gas and time, since generally purging is continued longer than needed. If an instrument was available which gave accurate measurements of hydrocarbons in inert gases, these disadvantages could be largely eliminated.

The most commonly used detector or analyzer utilizes a typical Wheatstone-bridge circuit and is used with an open and a sealed cell forming two of the four resistances of the bridge. Each cell contains a platinum resistance wire heated to incandescence by a battery current. By means of an aspirator the gas is caused to flow around the open cell, and a flashback arrester is used to prevent ignition of the surrounding gas by the incandescent element.

In operation the combustible gas oxidizes upon contact with the open filament, and the heat of combustion increases the filament temperature, thereby increasing filament resistance which in turn unbalances the bridge. A galvanometer indicates this change. The galvanometer may be calibrated against explosibility in terms of the percentage of the lower explosive limit for each mixture of an explosive gas in air. For hydrocarbon concentrations above the lower explosive and below the upper explosive limit, the instrument will read off-scale, i.e., explosive. For concentrations above the upper explosive limit readings may

be either on-scale or below zero. Such high hydrocarbon concentrations are easily distinguished from readings of zero percent hydrocarbon by observing the meter during a test with the meter initially filled with air. Because of sample dilution with the air in the meter, the reading will first go off-scale indicating "explosive." As sampling continues, the needle will return to an on-scale reading or zero depending upon the hydrocarbon concentration. These indications will be reversed upon clearing such a sample from the instrument with air.

Many of these instruments are standardized by balancing the resistances of the two cells when exposed to pure air and by adjusting the supply current to a fixed value by means of a variable resistance in series with the battery. It must be calibrated for each kind of explosive gas, or corrections obtained for gases other than that for which the original calibration was made.

In testing gases which are oxygen-free, it is necessary to first dilute the sample with air and then test the resulting mixture. With accurate air dilution equipment it is possible to analyze any mixture of inert gas and hydrocarbons and determine rapidly and accurately whether a flammable mixture would result upon dilution with air. If readings, for example, were safely below the lower explosive limit for all air concentrations, the system or unit under consideration could be safely purged with air.

Commercial devices are available which perform this air dilution, the most accurate being those having sample and air flows metered by rotameters and pumps. While these devices provide satisfactory data, they are far from portable and are not convenient for testing vents located high on a unit structure.

Another and simpler device is available which attaches to a portable detector. It consists of a variable orifice which fixes the percentage of air mixed with the sample. Several positions are provided in order to obtain different dilution ratios. This type of dilution attachment has a major disadvantage in field use in that the percentage of air dilution is very sensitive to the resistance of the sample line and will change as lines and orifices accumulate foreign matter or as different tube lengths are used. For example, it is known that for a given orifice setting, the percentage of air dilution can vary from 24% with a 1/8" tube 2 feet in length to 51% for the same diameter tube 4.5 feet in length to 69% for a like tube 15 feet in length. Under these conditions it is extremely difficult to obtain accurate readings.

It has now been discovered that many of these difficulties can be eliminated or substantially reduced through the utilization of the air dilution system in accordance with this invention. The air dilution system of this invention assures that a constant ratio of air to sample will enter the detector independent of any resistance changes in the line.

Briefly, this invention comprises a pneumatic bridge system connected to the aspirator means on the combustibles detector. The bridge has two inlet arms, one for air and one for sample. The air inlet arm has two valves, spaced one from the other, while the sample inlet arm has two orifice restrictions, spaced one from the other. A pressure differential detector is disposed between the two arms between the valves and the orifices for determining bridge balance. One of the valves is used to calibrate the system for the desired percent dilution. The other valve is used to balance the bridge while aspirating air and sample through the system, the balance being indicated on the detector. When a balance is reached the dilution is correct and the combustibles detector will indicate the lower explosive limit for that particular concentration of hydrocarbon and air.

Thus a simple dilution attachment has been provided which may be used with a portable combustibles detector

and which assures accurate dilutions despite any resistance in the sample line.

The full nature of the invention will be understood from the accompanying drawings and the following description and claims.

FIGURE 1 schematically shows one form of the pneumatic bridge system of this invention.

FIGURE 2 schematically shows another form of the pneumatic bridge system of this invention.

FIGURE 3 illustrates a calibration curve which may be utilized to calibrate the system.

Referring now to FIGURE 1, the bridge system comprises conduit arms 2 and 4. As illustrated in this figure, air enters conduit 2 and sample enters conduit 4 by means of an aspirator bulb on the combustibles detector (not shown).

The air and sample enter conduit 16 and are mixed as they enter conduit 18 which leads the combustibles detector.

Inlet arm 2 is equipped with valves 6 and 8. Valve 8 is used to calibrate the instrument for a desired air dilution. A number of positions are provided on the valve for this purpose. Valve 6 is used to balance the bridge system.

Inlet arm 4 is equipped with orifices 10 and 12. Each orifice has a hole diameter of about 0.016". These orifices may be conveniently constructed of ordinary shim material. The inlet conduits 2 and 4 may be constructed of standard tubing.

Pressure differential detector 14 is connected across the arms of the bridge, and is adapted to indicate bridge imbalance caused by any upstream resistance. Detector 14 is sensitive to bridge imbalance and will operate to measure pressure differences across the bridge upstream of valve 8 and orifice 12. Fundamentally, then, this network guarantees that the pressures ahead of valve 8 and orifice 12 will be equal.

In the preferred form, detector 14 is a horizontal manometer having a horizontally disposed capillary tube containing a droplet of oil or other liquid. When the droplet is motionless, this is a very sensitive indicator of a null balance across the bridge.

In operation air and sample are drawn through the system by operating the aspirator means of the combustibles detector. Usually this is in the form of a squeeze bulb. To obtain a particular dilution valve 8 is set according to a previous calibration. The calibration technique will be explained with reference to FIGURE 3. Valve 6 is then adjusted until there is little or no motion of the oil droplet in detector 14 during aspiration. Known dilution is thereby obtained regardless of sample line resistance as long as measurements are taken with detector 14 indicating a null balance or zero pressure differential across the bridge. As indicated above, under these conditions, this system assures that a constant ratio of air to sample will enter the combustibles detector independent of any resistance changes ahead of orifice 10.

While the above describes the preferred form of this invention, it is, of course, possible to practice this invention by positioning orifices 10 and 12 in air inlet conduit 2 and positioning valves 6 and 8 in sample inlet conduit 4. With this arrangement flow of sample would be regulated with respect to air and the same result could be achieved.

Referring now to FIGURE 2 another embodiment of the invention is illustrated. If one fixed dilution is desired, then valve 8 can be left in one position or, as illustrated in this figure, be replaced with fixed orifice 20. As before, valve 6 is adjusted each time to zero the bridge. Other than this one change, operation of the system is identical with that described above. It is merely necessary to select the orifice opening which gives the desired percentage air dilution.

FIGURE 3 is an example of a calibration curve which may be used in calibrating the instrument for desired

air dilution. The curve 22 is a plot of percentage air dilution versus the dial setting of valve 8. For example, for a desired air dilution of 20% the dial on valve 8 is set to 940. The instrument is now calibrated to give a dilution of 20% air. If a different dilution is desired, it is merely necessary to correspondingly change the setting of valve 8 to a different reading, i.e., 60% dilution—valve setting 800.

In constructing the air dilution attachment in accordance with this invention the Hoke Model 2RB285 needle valve may be used for valve 8 and an Ideal-Aerosmith 52-2-14 needle valve may be used for valve 6. As previously pointed out, ordinary shim material may be employed in making orifices 10, 12, and 20, and standard tubing may be utilized for conduits 2, 4, 16, and 18.

Typical combustibles detectors which are in common use and which may be employed in conjunction with this invention are the Mine Safety Appliance Company Explosimeter and the Davis Emergency Equipment Company Vapotester.

This invention is able to provide a continuous range of dilutions for a detailed investigation of operating problems in systems deficient in oxygen. And in addition to its use in systems containing hydrocarbons in inert gas, this invention can also be used to dilute over-rich, hydrocarbon-air mixtures to obtain on-scale readings. Through simple calculations the original hydrocarbon concentration may be determined. For example, if 50% dilution provides a meter reading of 80% lower explosive limit, then the original concentration was 160% lower explosive limit.

As mentioned previously, by simple calibration the combustibles detectors with which this invention may be used will respond to various hydrocarbon-inert gas-air systems. Examples would be isobutane, ethane, propane, methane, propylene, hexane, benzene, etc.

While the foregoing specification sets forth the invention in specific terms, it is to be understood that numerous changes in the shape, size, and materials may be resorted to without departing from the spirit and scope of the invention as claimed.

Having described the invention, what is claimed is:

1. The combination comprising:

first and second conduit means each having two spaced restrictions and respectively having air inlet means and sample inlet means, said conduit means merging at a point remote from said inlet means and said restrictions to form a common junction where air and sample are mixed together at a predetermined ratio;

third conduit means in advance of said common junction for interconnecting said first and second conduit means between two points intermediate said restrictions;

pressure differential detector means mounted along said third conduit means for indicating a pressure imbalance between said first and second conduit means; and

adjustable means at one of said restrictions for controlling pressure in said first and second conduit means so that pressure imbalance indicated by said detector means can be equalized to maintain said predetermined ratio of air and sample; and combustible detector means for detecting a combustible mixture of air and sample and having aspirating means coupled to said common junction.

2. The combination defined in claim 1 wherein another one of said restrictions has adjustable valve means movable to different calibrated positions to provide different predetermined mixtures of air and sample.

3. The combination defined in claim 1 wherein the two restrictions in the first conduit means are valves, and the two restrictions in the second conduit means are orifices.

4. The combination defined in claim 1 wherein, in

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said first conduit means, one restriction is a valve and the other restriction is a fixed orifice.

5. The combination defined in claim 1 wherein the pressure differential detector means is a horizontal manometer having a horizontally disposed capillary tube containing a liquid droplet.

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