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GAS ANALYZERS

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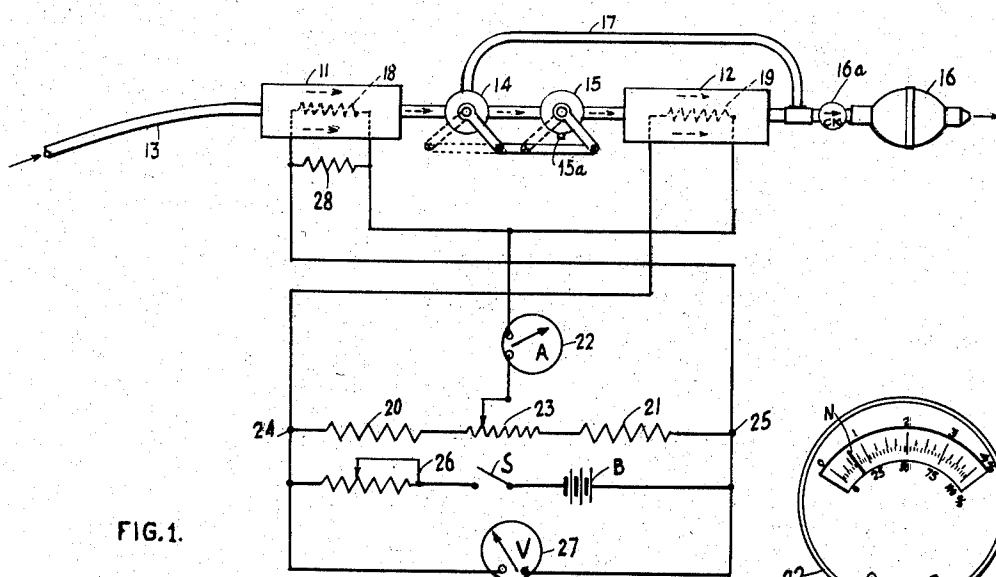


FIG. 1.

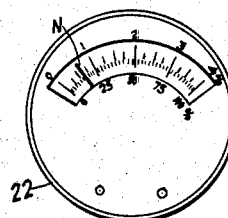


FIG. 4.

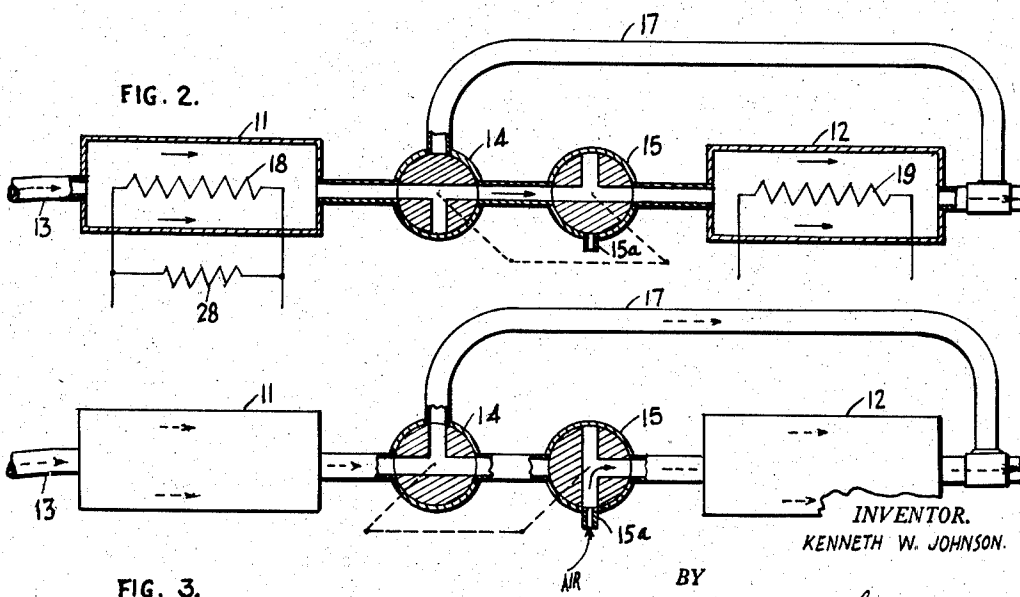


FIG. 3.

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GAS ANALYZERS

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This invention relates to the art of detecting and analyzing a gas component of an air-gas mixture. More particularly, the invention is concerned with improvements in the type of analyzer that will detect and analyze the gas content of a combustible gas-air mixture when the concentration of gas in the mixture is above the lower explosive limit as well as below the lower explosive limit and will provide scale readings covering the entire range from 0% to 100% of gas in the mixture.

In detecting and quantitatively determining the percentage of combustible gas admixed with air, it is common practice to use a heated catalytic filament and to bring the air-gas mixture into contact with the bare filament where oxidation of the combustible component of the mixture takes place by a catalytic reaction, thereby heating the filament and consequently raising its temperature. In practice, a platinum filament is used which rises in resistance in response to temperature increases. Such an analyzer will give an increasing reading with increasing gas concentration until a point is reached where explosions take place in the analysis cell, and erratic operation results. This point is above the lower explosive limit and below the theoretical combining proportions of the gas. The result is that the application of this type of instrument is confined to a range up to the lower explosive limit of the mixture. It has been found that if the percentage of gas in the mixture is increased beyond the upper explosive limit, the heat liberated at the filament is reduced, and at high concentrations of gas, an actual cooling effect is observed with a resulting downscale reading on the meter. Attempts have been made to indicate gas concentrations beyond this point by reversing the polarity of the meter, but, in general, they have not been completely satisfactory due principally to the erratic nature of the catalytic combustion process in this range. Furthermore, there is a range of concentrations, roughly from the lower explosive limit to somewhat above the upper limit which do not give an on-scale reading for either range. As a result gas analyzers, using the catalytic filament have been confined primarily to detecting and analyzing gas in the range below the lower explosive limit.

In addition to the catalytic filament mentioned there is another filament known as the thermal conductivity filament in which the temperature and resulting resistance of the filament is governed by the heat conduction and convection characteristics of the atmosphere and resistance having been established by passing an electric current through it while it is surrounded by air, will show a change in temperature and resistance if a mixture of gas and air is introduced to the space surrounding the filament. For those combustible gases of particular interest for the purpose of my invention, namely the fuel gases, including methane, hydrogen and propane, the effect of such mixtures will be to produce an increase in the rate of heat conduction from the filament and a consequent reduction in temperature of the filament.

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If the filament is made from a material such as platinum, tungsten or other metal having a positive temperature coefficient of resistance, the effect of increasing the percentage of gas in the sample will be to reduce the filament resistance. It will be noted that this is the opposite effect from that observed on the catalytic filament, which showed an increase in temperature and resistance when exposed to the gas. Each mixture of gas and air will result in a definite filament temperature and resistance and if the nature of the gas be known, the filament resistance can be used as a measure of the amount of gas in the mixture. A meter indicating current flow through the filament therefore may be calibrated to read directly the percentage of gas in the mixture. The thermal conductivity filament therefore can be used over the entire range from 0 to 100%. If calibrated in this way, however, it gives only a small reading at concentrations of gas below 5%, and for the purposes of establishing the presence of leaking fuel gases these small concentrations may be extremely important. Furthermore, the thermal conductivity filament is non-specific for combustible gases and will respond to other interfering gases as well, such as CO₂, H₂O or helium. Therefore, a thermal conductivity filament alone could not be used in a satisfactory combustible gas analyzer.

To provide a satisfactory instrument for the purpose of detecting and analyzing combustible gas-air mixtures over the entire range of 0% to 100%, it should combine both of the above-mentioned devices; that is, it should comprise a catalytic filament for detecting and analyzing combustible gas below the lower explosive limit and a thermal conductivity filament for determining the percentage of gas above the explosion point.

Broadly stated, my invention resides in a combination of the two types of gas analyzers mentioned, wherein I take advantage of the fact that in the conventional use of the catalytic filament, there is needed a reference filament to compensate for ambient conditions. In actual practice, the reference filament and the active filament are placed in series in a balanced circuit, such as a Wheatstone bridge. In my invention, I utilize the catalytic filament in the conventional manner, but instead of using an auxiliary filament as a reference, I use a thermal conductivity filament and balance these units in a Wheatstone bridge in the usual manner. The thermal conductivity filament becomes a reference unit for the catalytic unit and upon diversion of the sample from the catalytic unit to the thermal conductivity unit, the catalytic unit becomes a reference unit for the thermal unit. In this way, I incorporate both units in the same circuit and in conjunction with this circuit, I employ a novel flow system whereby the gas flow may be switched at will from one filament to the other to obtain a reading on the catalytic range from 0% to the lower explosive limit, approximately 4%, or on the thermal conductivity range from 0 to 100% of gas concentration in the sample under test, without reversing the meter or readjusting the circuit.

In using both the catalytic and thermal conductivity units in the same circuit either in series or singly, and subjecting them both to the same changes of equilibrium brought about by temperature variations in one or both of the sensing elements in order to get linear variations on the same meter when changing from one to the other, and at the same time provide great stability under ambient conditions, it was found advisable to compensate one of the units to meet the characteristics of the other. Also, the calibration of the meter will depend on the characteristics of the two sensing units used and these, in turn, will depend on the diameter, length, configuration and composition of the filaments per se. My

invention provides for these factors, as will be shown hereinafter.

The primary object of this invention is to provide a gas detecting and analyzing device comprising a catalytic and a non-catalytic sensing element that will give reliable readings of the gas content in an air-gas mixture on two scales covering the range from 0% to 100%, by changing the flow system from one sensing element to another in the same circuit without upsetting the equilibrium of the circuit.

Other objects and advantages will become apparent as the description proceeds in conjunction with the drawing in which:

Fig. 1 is a schematic view showing the component parts of my device diagrammatically.

Fig. 2 is an enlarged view showing the flow system, with the valves set for testing a sample in the range below the lower explosive limit.

Fig. 3 is a fragmentary view of Fig. 2 with the valves set for testing a sample above the explosive limit, and

Fig. 4 shows calibrations on a meter suitable for my invention.

Referring to the drawing, for a more detailed description of the invention, it can be seen in Fig. 1 that I have shown and illustrated my invention schematically and have diagrammatically illustrated the electrical circuit used in connection therewith. Broadly speaking, the invention comprises two essential components, namely, a flow system and an electrical network in conjunction with the flow system for electrically determining the percentage of gas in a mixture.

The invention in its preferred form, embodies two sensing units arranged in series in adjacent arms of a Wheatstone bridge. One of the units has a catalytic filament and the other a thermal filament. The flow system is arranged so that an operator may optionally control it to conduct a sample to be tested past either one of the filaments to get a reaction and force the other to play the part of a reference unit. For example, while gas is being tested on the catalytic filament, the thermal filament acts as a reference unit and when the thermal filament is operative, the catalytic filament becomes a reference unit. Under this arrangement, there are two different types of sensing units in the same system, both of which are essential to provide a complete analysis of gas content from 0 to 100%, and both of which perform alternately as an analyzer and as a reference unit. A single meter serves both arrangements, but in order to provide the proper correlation between the two ranges and give good stability, it was found necessary to match the filament characteristics of the units as closely as possible with respect to temperature, humidity, voltage, etc. This may be done experimentally by giving consideration to diameter, length, configuration and composition of the filaments. In the preferred embodiment of the invention, using a molybdenum thermal conductivity filament at a lower voltage than the catalytic platinum filament, stability of the system under ambient conditions was found to be improved by shunting a resistor across the thermal filament.

In Fig. 1, I have shown two sensing units, 11 and 12. These units may be defined as a thermal conductivity sensing unit and a catalytic sensing unit respectively. As shown, these units are connected in a flow system comprising a lead-in conduit 13 which, in practice, is connected to a probe (not shown) and is used to conduct a sample from the source to be tested to the sensing units. The sample is passed through unit 11 and enters a three-way valve 14, which valve works in conjunction with another three-way valve 15, to conduct the gas into the unit 12. It then passes through 12 and outwardly through an aspirator bulb 16. A check valve 16a must be incorporated in the system behind aspirator bulb 16. Under this arrangement, it will be noted that the sample passes through both sensing units (see Fig. 2). The

reason for this may be explained briefly as follows: In practice it was found that the response of the thermal filament to gas content in a mixture below the lower explosive limits was insignificant compared to the response of the catalytic filament and for all practical purposes could be ignored. However, in my invention, I substantially compensate for this discrepancy in the meter calibrations in the lower range. The advantages of using both units for sensing in the lower range instead of a single catalytic unit are numerous. The action of the filaments being additive, the sensitivity is increased where it is most useful. The flow of the sample through the system is improved and the whole assembly lends itself better to manufacturing practices. However, it is to be understood that the invention is not to be restricted to the single embodiment illustrated and shown since it is intended that the invention shall broadly comprise any arrangement of two sensing units of the character described wherein the units alternately play the part of analyzing gas in a mixture and of acting as a reference unit to the other in the same system.

When the valves 14 and 15 are turned to the position shown in Fig. 3, the flow of gas takes another route. Under this second arrangement the gas passes through the unit 11, but at valve 14, it is switched into a conduit 17, and bypasses the unit 12. At the same time, the valve 15 operates to admit air into the unit 12, which purges this unit of gas, and the unit becomes a reference unit for the first sensing unit 11, or the unit 12 may be isolated without air being admitted and allowed to come to ambient conditions normally. These valves may be coupled and operated at the same time, or they may be incorporated in the same valve body. For purposes of illustration, I have shown two three-way valves operating independently and coupled by mechanical means to work simultaneously.

In Fig. 2, it will be observed that as the sample to be tested passes through the unit 11, it encounters filament 18. This filament is a non-catalytic filament and being non-catalytic, the gas passing through the chamber will have no combustion effects upon the temperature of the filament, but will serve to dissipate the heat of the filament by convection and the conduction properties of the sample, and since the percentage and nature of the gas in the air mixture controls the rate of conduction and convection the temperature of the filament will vary proportionally to the nature of the gas passing through the chamber. The net result is an indication of the gas content in the air mixture by the rate of dissipation of the temperature of the filament. This naturally will be reflected in the resistance of the filament which can be read directly on a meter. As the gas passes into the chamber 12, it comes into contact with a filament 19, which, in this case, is a catalytic filament and sets up a combustion of the gas in the mixture, thereby raising the temperature of the filament, which in turn controls the electrical flow of current to be measured.

In conjunction with the flow system just described, I employ a divided electrical network, termed a Wheatstone bridge. As shown, this network comprises resistors 20 and 21 in separate arms of the bridge, with the sensing elements 12 and 11 connected in the corresponding arms respectively. An ammeter 22 is connected across the bridge to a potentiometer 23 between the resistor 20 and 21, and to a point between 11 and 12 on the output side of the units, and the input side of the units are connected to points 25 and 24 respectively on the bridge. This network corresponds to a Wheatstone bridge and under ambient conditions may be balanced by the potentiometer 23. Potential is supplied to the network by a battery B connected to the points 24 and 25, through a switch S and a voltage control rheostat 26. To provide good utility, a volt meter 27 may be placed across the battery as shown. The foregoing arrangement may be balanced and brought to a point of

equilibrium under ambient conditions by the rheostat 23, and any change in the resistance of the units 11 or 12 brought about by gas detection in either or both of the units will result in a flow of current through the ammeter 22. Polarity of the battery and meter is such that gas at either filament within its operating range, will result in an upscale meter reading. This in turn may be calibrated to indicate the percentage of gas which caused the disturbance.

In operation, the sample to be tested is brought in through the conduit 13 and is first passed through both sensing units 11 and 12. This is accomplished by means of the aspirator bulb 16, which is a well known operation. If the mixture to be tested is below the lower explosive limit, the catalytic action set up in unit 12 will be much greater than in 11 and 11 will in effect become a reference cell for 12. Unit 11 will however have a certain effect which will combine with the effect from unit 12 and will cause a flow of current through the meter 22 which, as before stated, is calibrated to read directly the percentage of gas up to this point. If, however, the concentration of gas in the air is above the explosion point or above the top scale reading on the meter, the valves 14 and 15 are then thrown to the positions shown in Fig. 3 which is the dotted line position in Fig. 1. It can be seen from these views that the gas then bypasses the unit 12 through the conduit 17 and that air only is admitted to the filament 19 through a small orifice 15a. The filament 18 then becomes the sensing unit and the filament 19 becomes a reference unit. But since 18 is a non-catalytic filament and is responsive to the percentage of gas in the mixture, through the property of the mixture to conduct and dissipate the heat away from the filament, it will cause current to flow through the meter which may be calibrated to read directly the percentage of gas in the mixture. It might be stated here, that the small orifice 15a may be omitted and no air admitted to the unit 12 with generally good results, the only difference being that a short wait might be necessary to allow unit 12 to adjust normally to ambient conditions.

In Fig. 4, I have shown the meter 22 with one form of calibrations suitable for my invention. It will be noted the dial comprises two sets of indicia, an upper and a lower. The upper set runs from zero to four percent, which would correspond roughly to the lower explosive limit of methane, while the lower shows from zero to one hundred percent.

In testing for percentages of gas in mixtures, the catalytic sensing unit is ordinarily used first, and if the mixture is below the explosion point, it will show a reading on the upper scale. This scale is shown as extending up to 4%, which in this case corresponds to the lower explosive limit. Gases will explode above the lower explosive limit, and the catalytic filament will become erratic and useless. For higher percentages, the flow system is changed to conduct the sample past the thermal unit alone, and ambient air is admitted to the catalytic filament. The needle N then drops back to indicate percentages on the lower scale and to be accurate and reliable should show a continuity of readings from one scale to the other. This, as before stated, is accomplished by designing the filaments, taking into consideration the diameter, length, coil configuration, and composition of the filaments. To provide improved stabilization of the circuit under ambient conditions, on the preferred embodiment of my invention, I install a resistor 28 in parallel with the filament 18.

Having shown and described a single embodiment of my invention, I intend this disclosure to cover all modifications, refinements, alterations and substitutions that

come within the scope of the disclosure and the purview of the appended claims.

I claim:

1. In combination, a Wheatstone bridge having a thermal filament in one arm thereof and a catalytic filament in series with said thermal filament in an adjacent arm of said bridge with a meter arranged to indicate a balance of voltage across said bridge, a flow system arranged to conduct a sample of an air-gas mixture past both of said filaments and means in said flow system for optionally conducting said sample past said thermal filament only and admitting air to said catalytic filament to derive readings on said meter to indicate the content of gas in said mixture.

2. An apparatus for analyzing the gas component of an air-gas mixture comprising a first sensing unit, a second sensing unit, a flow system for conducting an air-gas mixture past said second sensing unit to derive a catalytic reaction therefrom and cause said first sensing unit to act as a reference unit, and means in said flow system for conducting said air-gas mixture past said first sensing unit to derive a thermal conductivity determination of the gas content in said air-gas mixture and admit air to said second sensing unit.

3. In a system for analyzing the gas component of an air-gas mixture, a pair of sensing units, a flow system for conducting an air-gas mixture past said sensing units to derive a combined reaction of said units to indicate the gas content of said mixture, and means in said flow system for optionally conducting said air-gas mixture past one of said sensing units to derive a thermal conductivity reaction thereon and admit air to the other of said sensing units.

4. In combination, a first resistor whose resistance is affected by changes in thermal conductivity of gases and vapors in contact therewith, a second resistor whose resistance is affected by the catalytic action of gases and vapors in contact therewith, a flow system for conducting an air-gas mixture past said second resistor to indicate the gas content in said mixture, and means in said flow system for conducting said air-gas mixture past said first resistor and admitting air to said second resistor to indicate the gas content in said mixture.

5. In combination, a catalytic filament, a thermal conductivity filament, a flow system for conducting an air-gas mixture past said catalytic filament to determine the gas content in said mixture, said flow system having means for optionally conducting said mixture past said thermal conductivity filament only and admitting air to said catalytic filament to indicate the gas content in said air-gas mixture.

6. In combination, a bridge circuit, a first sensing unit whose resistance is affected by a change in the thermal conductivity of an air-gas mixture in contact therewith in one leg of said bridge, a second sensing unit whose resistance is affected by a catalytic reaction of gases and vapors in contact therewith in an adjacent leg of said bridge, a flow system for conducting an air-gas mixture past said second sensing unit, means in said flow system for optionally passing said air-gas mixture past said first sensing unit and admitting air to said second sensing unit, and means connected to said bridge circuit for indicating resultant changes in resistance of said sensing units.

References Cited in the file of this patent

UNITED STATES PATENTS

2,618,150 Willenborg ----- Nov. 18, 1952

FOREIGN PATENTS

250,478 Great Britain ----- Apr. 15, 1926

494,754 Great Britain ----- Oct. 31, 1938