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Venema

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[54] **BREATH TESTING SYSTEM WITH INCREASED SENSITIVITY**

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[58] **Field of Search** ..... 128/2 C, 2 R, 2.07; 73/27 R; 23/232 E, 254 E, 255 E; 340/237

[56] **References Cited**

UNITED STATES PATENTS

1,992,747	2/1935	Gilliland et al.	340/237 R
2,114,401	4/1938	Price	340/237 R
2,234,128	3/1941	Miller	23/232 E
2,244,366	6/1941	Jacobson et al.	23/232 E
2,683,793	7/1954	Gilmont et al.	340/237 R
3,147,465	9/1964	Brown et al.	340/237 R
3,239,828	3/1966	Peterman	340/237 R
3,600,134	8/1971	Noller	23/232 E

FOREIGN PATENTS OR APPLICATIONS

464,798	4/1937	Great Britain	340/237 R

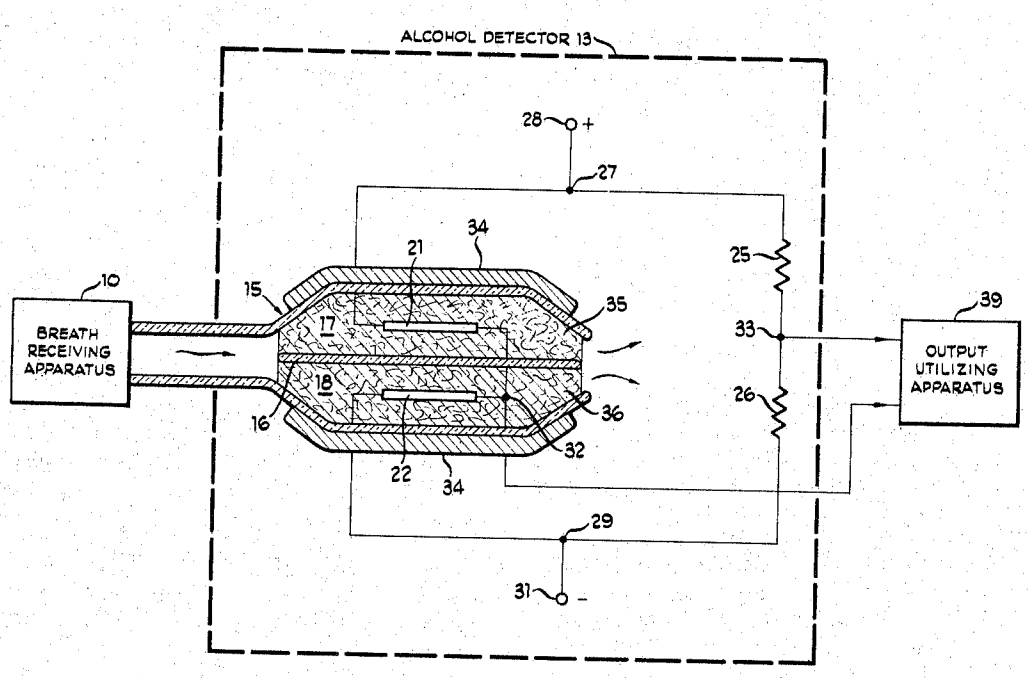
Primary Examiner—Kyle L. Howell

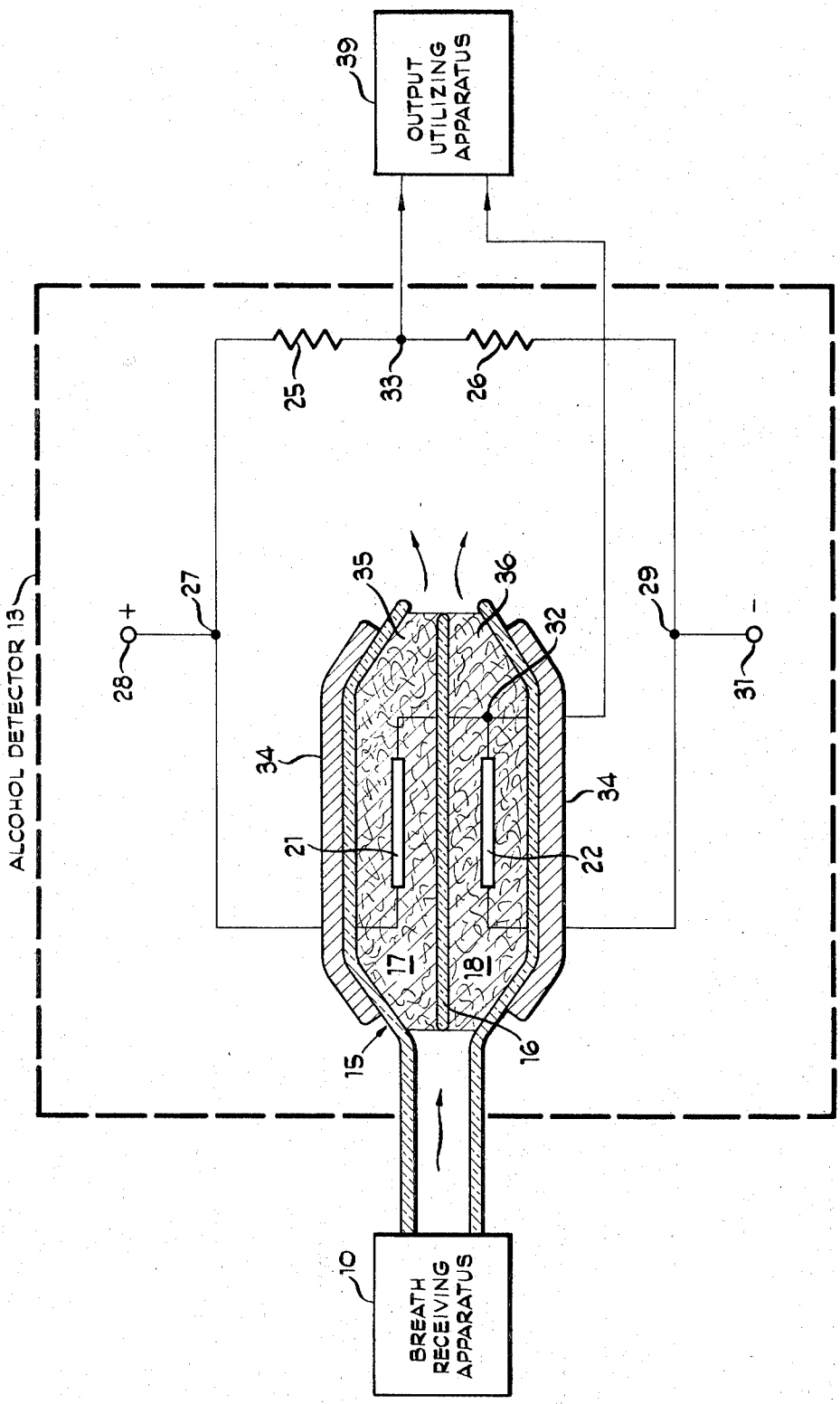
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[57] **ABSTRACT**

Increased sensitivity to alcohol content of a subject's breath is obtained in a catalytic oxidation or combustion detector by flowing a breath sample through a heated chamber containing a maze of substrate elements, such as fibrous glass wool, coated with a catalytic material and providing a total catalytic surface area which is very large compared to the mass of the substrate elements. The alcohol constituent oxidizes as the molecules contact the catalytic material, and as a result of the oxidation reaction the temperature increases in an amount directly proportional not only to the alcohol concentration but also to the catalytic area/mass ratio. A temperature-sensing device, such as a thermistor, responds to the temperature change and effects the development of an output information signal, the amplitude of which accurately represents the breath alcohol concentration.

1 Claim, 1 Drawing Figure




39
OUTPUT UTILIZING APPARATUS
ALCOHOL DETECTOR 13
25
33
26
27
28
+
35
36
32
29
31
-
34
34
21
22
17
18
15
16
10
BREATH RECEIVING APPARATUS

BREATH TESTING SYSTEM WITH INCREASED SENSITIVITY

BACKGROUND OF THE INVENTION

Various breath testing systems have been developed for evaluating a person's breath to detect its alcohol level. In one well known system, a sample of the breath to be analyzed is passed over a heated catalyst resistance element where any alcohol present in the breath sample oxidizes. The heat of the oxidation reaction causes the temperature and consequently the resistance of the catalytic element to increase, and this in turn causes an output information signal to be produced which indicates the particular alcohol level in the breath sampled. Usually, the catalytic element forms one leg of a normally-balanced wheatstone bridge which unbalances when the resistance of that element changes as a result of oxidation of breath alcohol, the degree of unbalance being proportional to the alcohol concentration.

In its simplest form, the heated catalyst resistance element is a platinum wire which constitutes a catalyst as well as a thermistor, namely a resistor whose resistance varies with temperature. The required heating is accomplished by constantly flowing quiescent or steady-state current through the platinum wire. The molecules of the breath sample must come in contact with the platinum wire to react and cause the temperature of the wire to increase. However, since the surface area of the wire is relatively small, a small number of molecules will contact it. The temperature and resistance of the wire will therefore increase very little in the presence of alcohol, resulting in an alcohol detector of low sensitivity. In many cases the detector includes a combination heater-thermistor element around which is wrapped a bead or sleeve formed of some catalytic material. The surface area of the bead is much larger than that of the platinum wire so that considerably greater contact will be made with the molecules of the breath sample, and a greater temperature and resistance increase will occur for a given alcohol concentration as compared to the case of the platinum wire.

Of course, the greater the temperature change in response to a given alcohol concentration, the greater will be the detector's sensitivity and the more accurate the test results. Hence, it is most desirable to maximize the catalytic surface area contacting the molecules of a breath sample, and preferably this should be done without significantly increasing the physical size and/or cost of the breath analyzing equipment. This objective has been achieved by the alcoholic breath analyzer of the present invention. Within a very small space, a breath sample contacts a relatively large catalytic surface area to effect a measurable temperature change in response to the slightest variation in alcohol content. As a result, the breath testing system herein disclosed performs an extremely accurate test, and yet this is accomplished without employing highly sophisticated, complex and expensive testing apparatus.

SUMMARY OF THE INVENTION

The breath testing system of the invention determines the breath alcohol concentration of a person and comprises means for providing a heated chamber, within which is disposed a temperature-sensing device, such as a thermistor, having a predetermined characteristic that varies with temperature changes in the chamber. There is also located within the chamber an alcohol-oxidizing means which includes a maze of substrate elements each coated with a catalytic material to obtain a relatively high ratio of total catalytic surface area to total mass or weight. This will maximize the number of molecules, of any gas sample passed through the maze, that will come in contact with the catalytic material. Breath receiving apparatus provides a sample of breath received from a person to be tested. There are means for supplying the breath sample to the heated chamber and through the maze where any alcohol present in the sample oxidizes. The oxidation reaction releases thermal energy to increase the temperature in the chamber in direct proportion to the alcohol concentration and in direct proportion to the catalytic area/mass ratio. The maze thus effectively increases the sensitivity of the alcohol-oxidizing means to breath alcohol. An alcohol detector, which includes the alcohol-oxidizing means and the temperature-sensing device, develops an output information signal indicative of the alcohol concentration.

DESCRIPTION OF THE DRAWING

The features of the invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further advantages and features thereof, may best be understood, however, by reference to the following description in conjunction with the accompanying drawing, the single FIGURE of which is a diagram, partly in block form and partly in schematic, of a breath testing system constructed in accordance with one embodiment of the invention.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENT

Breath receiving apparatus **10** develops a measured sample of breath received from a subject under test. The apparatus may take any suitable construction to facilitate the receipt of breath blown or exhaled by the person and to deliver a sample of that breath to the outlet of the apparatus, the unused breath being vented or dumped to the atmosphere. One example of an appropriate form for apparatus **10** is found in copending application Ser. No. 136,778, filed Apr. 23, 1971 in the names of Donald W. Collier, Joseph P. Hoppesch and Anthony C. Mamo, and issued Oct. 9, 1973 as U.S. Pat. No. 3,764,270.

While not essential for the proper operation of the present invention, apparatus **10** preferably includes appropriate control equipment to make certain that the breath sample constitutes deep lung breath. Suitable control equipment to perform that function is also illustrated and described in the aforementioned copending application Ser. No. 136,778. There, a breath sample is not produced at the outlet of the breath receiving apparatus until a continuous uninterrupted breath flow has occurred for a predetermined time period, such as 5 seconds. A sample taken at the end of a 5-second interval of uninterrupted blowing or exhaling constitutes deep lung breath, from which an accurate reading of alcohol level may be obtained as is well known in the art.

The alcohol concentration in the deep lung breath sampled is determined by an alcohol detector **13** which develops an electrical information signal, the amplitude

of which reflects the breath alcohol level. More particularly, each breath sample from apparatus **10** is channeled to one end of a tubular or cylindrical shaped enclosure **15,** made for example of glass or plastic, the other end of which opens to the atmosphere. A flat separating wall **16,** which may also be constructed of glass or plastic, divides cylindrical tube **15** into two halves to provide two chambers **17, 18** of equal volume. With this construction, a breath sample emanating at the outlet of apparatus **10** is split by wall **16** into two equal portions, one of which flows through chamber **17** and then to the atmosphere via the open end of tube **15,** while the other portion simultaneously flows through chamber **18** and thence to the atmosphere.

Each chamber, which is heated in a manner to be explained, contains a temperature-sensing device for measuring or recording the temperature within the chamber. These devices, labeled **21** and **22,** have predetermined characteristics or properties that vary with temperature. Preferably, devices **21** and **22** are identical thermistors whose resistances vary in response to temperature variations.

Thermistors **21** and **22** are included in and form part of a normally-balanced, four-legged wheatstone bridge. Specifically, thermistors **21** and **22** constitute respective ones of two adjacent legs of the bridge circuit. A pair of simple, equal size resistors **25** and **26** function as the other two adjacent legs. Bridge junction **27** connects to the positive terminal **28** of a source of D.C. operating potential, while junction **29** is connected to the negative terminal **31** of that potential source. Direct current therefore flows continuously from positive terminal **28** to negative terminal **31** through two parallel paths — one provided by legs **21** and **22** and the other by legs **25** and **26.** The constant current flow through devices **21** and **22** produces heat to heat chambers **17** and **18.** Preferably, however, the required heating of chambers **17** and **18** is accomplished by a separate cylindrical shaped heater **34** which forms a jacket around the outside of tube **15.** Heater **34** may, for example, be a heating coil through which current passes.

Since thermistors **21** and **22** normally have the same resistance and since resistors **25** and **26** are of equal electrical size, in the absence of any external stimulation the bridge circuit will be balanced and junctions **32** and **33** will be established at identical voltage levels. The output of alcohol detector **13** is derived between junctions **33** and **32** and with a zero voltage difference existing between those junctions no output signal will be developed by alcohol detector **13.** The output signal will also have zero amplitude when a breath sample, containing no alcohol, is delivered to heated chambers **17** and **18** from apparatus **10.** The alcohol-free breath will flow through those chambers and to the atmosphere without causing any chemical reaction and/or temperature change. Detector **13** will be unresponsive to the breath sample.

In accordance with the present invention, a very small amount of breath alcohol will upset or unbalance the bridge circuit to produce an output signal having a finite amplitude precisely representing the alcohol concentration. In other words, alcohol detector **13** is extremely sensitive to the presence of breath alcohol and a very small change in alcohol concentration results in a measurable change in the amplitude of the output signal to provide a read-out which accurately depicts the alcohol level. This is accomplished by causing the temperature in chamber **17** to vary to a substantial extent in response to the slightest change in breath alcohol concentration.

More particularly, a maze or bulk of substrate elements, preferably formed of glass wool fibers, is included in each of chambers **17** and **18.** Of course, the fibers are sufficiently loosely packed into each chamber to permit breath flow through the entire length of tube **15.** Each of the substrate elements or fibers of the maze (labeled **35**) in chamber **17** is coated with a catalytic material, while the maze **36** of substrate elements in chamber **18** remains uncoated. Hence, maze **35** serves as an alcohol-oxidizing means since any alcohol in the breath sample flowing through chamber **17** oxidizes as it contacts the catalytic material. By employing the maze **35** of catalyst-coated substrate elements, there is obtained a total catalytic surface area which is very large compared to the mass or weight of the substrate elements. This will maximize the number of molecules coming in contact with the catalytic material so that the thermal energy released by the oxidation reaction effects a substantial temperature increase within chamber **17** even in response to low alcohol concentrations. This follows inasmuch as the temperature change will vary in direct proportion to the catalytic area/mass ratio as well as in direct proportion to the alcohol concentration. Preferably, the catalyst coated substrate elements should also have a thermal capacitance as low as possible since the temperature increase is inversely proportional to the thermal capacitance.

Temperature-sensing device **21** increases in resistance in response to the temperature increase and to an extent directly proportional to the alcohol level. Meanwhile, the non-catalytic maze **36** in chamber **18** is unresponsive to the alcohol in the breath flowing through that chamber and thus the resistance of device **22** remains unchanged. With unequal resistances for thermistors **21** and **22,** the bridge circuit becomes unbalanced as the voltage drops in those thermistors will be unequal and this causes junction **32** to be established at a voltage different than that at junction **33.** The magnitude of the differential represents the degree of unbalance and the particular alcohol level in the breath sampled. The output information signal, produced between junctions **33** and **32** and applied to output utilizing apparatus **39,** therefore has an amplitude directly proportional to and representing the breath alcohol concentration.

Output utilizing apparatus **39** may include a meter which effectively measures the information signal amplitude, thereby providing a visual display of the alcohol concentration in the tested breath sample. Alternatively, the output apparatus can be a simple bulb energized when the information signal exceeds a predetermined threshold amplitude level.

Apparatus **39** may take any of a variety of different forms inasmuch as there are many devices that can be controlled by an electrical signal whose amplitude signifies the alcohol level of a person's breath.

Of course, an amplifier may be interposed between alcohol detector **13** and apparatus **39** so that the information signal may be amplified before it is applied to the output utilizing apparatus. No amplifier is illustrated in order to simplify the drawing as much as possible.

It is to be understood that the invention need not be embodied in a bridge type alcohol detector, but may be

incorporated in any alcohol detector of the type having a catalyst which oxidizes breath alcohol and produces a temperature change to in turn effect the development of an output information signal reflecting the alcohol content. For example, the detector may merely comprise a single thermistor through which direct current continuously flows and around which a breath sample flows through a maze of catalyst coated substrate elements to produce an oxidation reaction to vary the temperature of the thermistor thereby varying the current therethrough. The detector's output signal would be determined by the current flowing through the thermistor.

Of course, in the illustrated embodiment the advantages of the present invention are combined with those achieved in a conventional bridge type detector. For example, since the adjacent legs provided by devices **21** and **22** are (with the sole exception of the catalytic material in chamber **35**) located in identical environments, are identical in construction and are simultaneously exposed to the same breath sample, any change in either one of those legs caused by thermoconductivity, convection, etc., will be balanced out by an equal and compensating change in the other leg. In addition, current changes due to power supply variations are also cancelled out. If desired, the invention could be incorporated in an AC bridge rather than the DC bridge illustrated.

The invention provides, therefore, an improved breath alcohol detection system of the catalytic oxidation or combustion type that achieves a substantially greater sensitivity to alcohol content than previously possible in similar type breath analyzers. This is accomplished by utilizing a maze of catalyst covered substrate elements to increase the area contact between the gas molecules and the catalyst.

While a particular embodiment of the invention has been shown and described, modifications may be made, and it is intended in the appended claims to cover all such modifications as may fall within the true spirit and scope of the invention.

I claim:

1. A breath testing system for determining the breath alcohol concentration of a person, comprising:

means for providing a heated chamber;

a temperature-sensing device within said chamber and having a predetermined characteristic which varies with temperature changes in said chamber;

alcohol-oxidizing means within said chamber and including a maze of substrate elements, formed of glass wool fibers having a relatively low thermal capacitance, each of which elements is coated with a catalytic material to obtain a relatively high ratio of total catalytic surface area to total mass and to maximize the number of molecules, of any gas sample passed through said maze, that will come in contact with the catalytic material;

breath receiving apparatus for providing a sample of breath received from a person to be tested;

means for supplying said breath sample to said heated chamber and through said maze where any alcohol present in said breath sample oxidizes, the oxidation reaction releasing thermal energy to increase the temperature in said chamber in direct proportion to the alcohol concentration in said breath sample and in direct proportion to said ratio, said maze thereby effectively increasing the sensitivity of said alcohol-oxidizing means to breath alcohol;

and means, coupled to and controlled by said temperature-sensing device, for developing an output information signal having an amplitude directly proportional to the alcohol concentration in said breath sample.

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