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APPARATUS FOR GAS ANALYSIS

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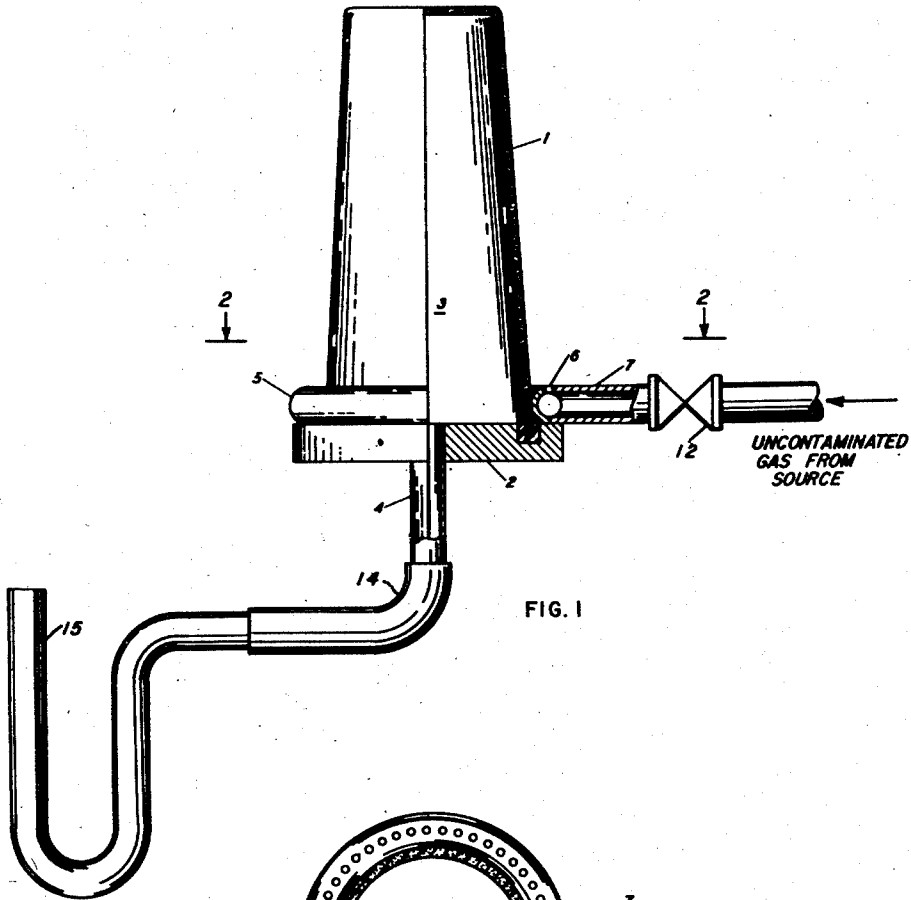


FIG. 1

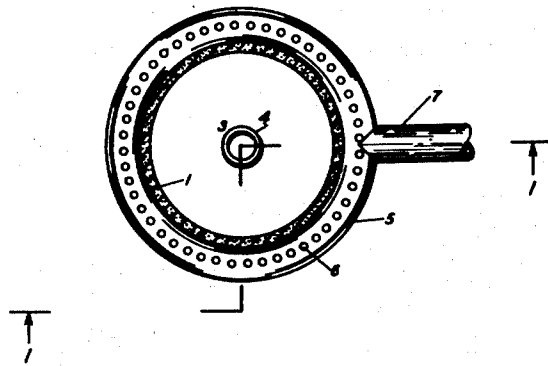


FIG. 2

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APPARATUS FOR GAS ANALYSIS

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1

The invention herein described may be manufactured and used by or for the Government for governmental purposes without the payment to me of any royalty thereon.

This invention relates to diffusion of gases, and more especially to a method and apparatus for detecting the presence in air of gases not ordinarily found in air, for example, hydrogen, carbon monoxide, carbon dioxide, methane, etc.

It has long been known that a diffusion cell made up of two chambers separated by a porous wall pervious to gas can be used to indicate the presence in air of a small amount of certain gases such as hydrogen, carbon monoxide or methane. In accordance with known physical laws the velocity at which a gas diffuses through a porous wall pervious to gases is inversely proportional to the square root of the density of the gas. Thus, if two gases of different densities are placed in separate chambers separated by a permeable wall, the lighter of the two gases will diffuse from its chamber to the other chamber more rapidly than the heavier gas will diffuse from its chamber to that of the lighter gas. Consequently, for a short time, there will be an increase in pressure in the chamber which originally contained the heavier gas, and a decrease in pressure in the chamber which originally contained the lighter gas. In the prior art a known gas has been confined in a relatively small space enclosed by a porous, gas-pervious wall, the unknown gas passed over the porous wall, and the change in pressure of the known gas measured. The prior art also points out that the volume of the known or standard gas should be small compared with the area of the porous wall. In each case it is necessary to renew the standard gas before another measurement is made.

The principal object of the present invention is to provide a method for detecting the presence in air of hydrogen or other inflammable or noxious gases. Another object of this invention is to provide a method for indicating the presence and amount of gases of one density in a gas of a different density. A further object of this invention is to provide a method for gas analysis by diffusion which may be performed rapidly and accurately with a minimum of attention. Other objects of this invention include the provision of an apparatus for carrying out the methods indicated in the foregoing objects.

The present invention is directed to apparatus for analyzing a gaseous mixture containing a substantial proportion of a gas of constant composition and density for the presence therein of

2

variable amounts of another gas of different density by establishing a condition in which said gaseous mixture is present under substantially equilibrium conditions both inside and outside a zone defined by a gas permeable wall, by rapidly displacing the gaseous mixture in juxtaposition with the outside of said wall with the gas of constant composition and density free from the presence of the gas of different density, and by measuring the resulting pressure change in said enclosed zone.

In the accompanying drawings which form a part of the specification, and wherein reference symbols refer to like parts wherever they occur,

Fig. 1 is a vertical, part-sectional view of one form of apparatus for the embodiment of the present invention taken through 1—1 of Fig. 2, and

Fig. 2 is a plan sectional view taken through 2—2 of Fig. 1.

A hollow thimble 1, with a gas permeable wall, is sealed to a base 2, to form space 3. A tube 4, through base 2, connects said space 3 with a suitable pressure indicating device 15 via line 14. The hollow thimble 1 is surrounded by a manifold 5 having a plurality of apertures, represented by aperture 6, or slits or a single slit so located that known gas entering the manifold from conduit 7 containing valve 12 is directed in a stream along the exterior walls of thimble 1.

In tests using the apparatus to detect the presence of hydrogen, it was found that a porcelain bacteriological filter thimble gave the best results. This thimble had a porosity designation of 0.3, which corresponds to a maximum pore diameter of 1.3 microns.

The tube 4 was attached to a small, open end, glass manometer. The manometer fluid used was water. The apparatus was operated in a vertical position. Air at 10 pounds per square inch pressure was fed to the manifold for a few seconds at 5 minute intervals. In the absence of hydrogen in the air surrounding the thimble, no motion of the manometric fluid was observed when the external surface was swept with air from the manifold. However, when the thimble was surrounded by air containing as much as 1 per cent hydrogen and 1 minute allowed for attainment of equilibrium, a displacement of approximately 10 mm. in the manometric fluid was observed when the external surface was swept with air. Maximum displacement of the fluid was reached within approximately one-half second from the time the air blast was begun. A period of from 2 to 5 minutes between air blasts was found to

allow sufficient time for reattainment of equilibrium.

Since the displacement of the manometric fluid is proportional to the difference in partial pressure of the foreign gas on either side of the porous wall at the instant the external surface is swept by the air, the apparatus can be calibrated to detect various concentrations of the foreign gas by measuring the maximum pressure change for each concentration of foreign gas. This was done very roughly. Concentrations of hydrogen around 1 per cent produced a liquid level differential of 10 mm., 3 per cent produced a 15 mm. differential, while concentrations of hydrogen above 20 or 25 per cent produced such a differential that the manometric fluid was forced out of the tube.

According to this invention a porous, gas-permeous chamber is placed in an atmosphere in which it is desired to detect the presence of foreign gases. An equilibrium condition in which the atmosphere or gas inside the chamber is the same as that outside the chamber becomes established, after which a stream of a known gas is passed over the outer surface of the porous chamber at a velocity sufficient to sweep away the atmosphere immediately adjacent to the chamber and establish a layer of known gas in contact with the outer surface.

The known gas ordinarily used has the same composition and density as the atmosphere being tested, and is completely free of the foreign gases to be detected. During passage of the known gas over the chamber, the presence of a foreign gas inside the chamber will be evidenced by a change in pressure inside the chamber. If the density of the foreign gas is greater than that of the known gas, diffusion of the known gas into the chamber will be more rapid than diffusion of the foreign gas from the chamber, resulting in increased pressure inside the chamber. If the density of the foreign gas is less than that of the known gas, as is the case when testing for hydrogen, diffusion of the foreign gas from the chamber will be more rapid than diffusion of the known gas into the chamber, resulting in a decrease of pressure inside the chamber. If there is no foreign gas in the atmosphere, and therefore none in the chamber, and if the density of the known gas is the same as that of the atmosphere being tested, diffusion of the known gas into the chamber will progress at the same rate as diffusion of the atmosphere from the chamber, and there will be no change in pressure inside the chamber. Presence of foreign gas in the atmosphere, as evidenced by change in pressure within the chamber, is indicated by a suitable pressure indicating device connected to the inside of the chamber. The pressure-indicating device may be calibrated to indicate the amount of a given foreign gas in the atmosphere, or it may be provided with means for activating an alarm device when a predetermined concentration of the foreign gas is reached.

Passage of air or other known gas over the chamber is continued for a period of time sufficient to give measurable results, after which the flow is stopped. In operation, known gas is passed intermittently over the chamber, and enough time is allowed between passes to permit reestablishment of equilibrium between the atmosphere and the inside of the chamber. Any period of time greater than the minimum necessary to obtain equilibrium may be employed, as desired.

Intermittent flow of air or other known gas may be accomplished by means of a manually operated or motor-driven stopcock, or by means of a solenoid-operated valve. It is desirable to use a pressure regulator in the air supply line so that the rate of air flow over the chamber is kept within certain limits in successive air passages. The rate should be high enough to sweep away the ambient atmosphere but not so high as to create sufficient turbulence to cause super-atmospheric pressure on the surface of the chamber. With automatic operation, in which the time occupied by each successive air passage is the same, and with pressure regulation of the air supply, very satisfactory comparative results are obtained.

The rate of attainment of equilibrium between the chamber and the atmosphere can be accelerated, if desired, by placing an impermeable plug inside the chamber to reduce the volume without reducing the area of the permeable surface.

Other possible variations include change in shape of the porous chamber, use of a chamber in which only a portion of the wall is porous, and use of a slitted or fan-shaped air distributor in place of the circular manifold. In addition, the enclosed space could be filled with the unknown atmosphere by mechanical means; the diffusion method described above, however, is simpler and more desirable. Other variations are also possible without departing from the principle of establishing equilibrium between the two sides of a porous wall exposed to an atmosphere being tested, and then momentarily displacing the atmosphere on one side of the porous wall by a stream of known gas.

The main advantage of both the method and apparatus lies in the simplicity of operation. In all the prior art devices, a sample of known gas must be obtained, introduced into the pressure-measuring chamber, and maintained without contamination until the test is begun. This method has several disadvantages. In the first place, several valves are required, the manipulation of which complicates the operating procedure. One device, for example, requires four valves to control the sampling and flow of the gases. Each of these must be operated in making a test. In contrast, the present device has only the one valve, thus reducing considerably the number of manipulations involved.

The principal difficulty in the prior art, however, is in maintaining the sample of known gas without contamination and at the proper pressure. The sample in each case is taken before the test and must be kept uncontaminated by the foreign gas until the test is begun. Thus, leaking valves, insufficient purging, and other possible mishaps in operation will cause contamination of the sample and consequent error. In the present invention, however, there is no necessity to confine a sample of gas in the apparatus. The porous chamber is merely exposed to the atmosphere to be tested until the content of foreign gas is the same inside and outside the chamber, and a stream of known gas is then blown along the outer surface. There is no chance for contamination of sample because none is taken. In addition, the chamber need not be purged after each test.

Also, as mentioned above, the necessity for the pressure inside the porous chamber at the beginning of the test being the same as that of the atmosphere being tested introduces a difficulty into operation of the prior art devices. It is well

5

known in the art of gas sampling that obtaining a sample of gas in which the final pressure is atmospheric from a source in which the gas is at superatmospheric pressure is very difficult unless the pressure is adjusted after the sample is taken. The prior art shows no provision for the latter, and if it did, an additional manipulation would be introduced which is unnecessary in the present invention. In the latter the air from the cylinder or compressed air line expands immediately to atmospheric pressure as it emerges from the manifold, thus ensuring atmospheric pressure both inside and outside the chamber without necessity for any adjustments. At extremely high rates of flow, the pressure on the outer surface of the chamber might exceed atmospheric because of turbulence in the air stream, but this does not occur at the relatively low rates of flow used.

The advantages of the present invention stem from the dynamic method of operation as compared to the static methods of the prior art. The result is that the device is simpler to construct, operation is less complicated, and the chance of mechanical error is substantially decreased.

It will be seen, therefore, that this invention may actually be carried out by the modification of certain details without departing from its spirit and scope.

I claim:

1. An apparatus for analyzing an atmosphere of known density to determine contamination thereof by a foreign gas of different density which comprises, in combination, a nonpervious base having an opening therethrough; a porous porcelain thimble having a maximum pore diameter of about 1.3 microns sealed to said base and cooperating therewith to enclose a chamber, and adapted to be freely exposed to an atmosphere; a tube disposed in said opening in gas-tight relationship to said base, communicating with the interior of said chamber; a manometer disposed outside said chamber, attached to and communicating with said tube in pressure-responsive relationship therewith; and means for sweeping away the atmosphere in contact with the outer surface of said porous thimble and establishing a layer of gas of known density in contact therewith comprising a source of gas of known density and under pressure, a conduit communicating therewith, a valve adapted to interrupt flow of gas disposed in said conduit, and a manifold attached to and communicating with said conduit on the opposite side of said valve from said source of gas pressure, disposed to surround said thimble adjacent to said base and having openings adapted to emit gas adjacent to the outer surface of said thimble.

2. An apparatus for analyzing an atmosphere of known density to determine contamination thereof by a foreign gas of different density which comprises, in combination, a nonpervious base having an opening therethrough; a porous

6

gas-pervious thimble sealed to said base and cooperating therewith to enclose a chamber, and adapted to be freely exposed to an atmosphere; a tube disposed in said opening in gas-tight relationship to said base, communicating with the interior of said chamber; pressure-responsive means for indicating pressure attached to and communicating with said tube; and means for sweeping away the atmosphere in contact with the outer surface of said porous thimble and establishing a layer of gas of known density in contact therewith comprising a source of gas of known density under pressure, a conduit communicating therewith, a valve adapted to interrupt flow of gas disposed in said conduit, and a manifold attached to and communicating with said conduit on the opposite side of said valve from said source of gas under pressure, disposed to surround said thimble and having openings adapted to emit gas adjacent to the outer surface of said thimble.

3. An apparatus for analyzing air to detect and estimate quantitatively the contamination thereof by a gas of different density which comprises, in combination, a diffusion cell adapted to be freely exposed to surrounding air and comprising a nonpervious base and a porous gas-pervious thimble sealed thereto, cooperating to enclose a chamber; a tube disposed in a gas-tight relationship through a wall of said chamber, communicating with the interior of the chamber and adapted to transmit gas pressure from within the chamber to a point outside the chamber; pressure-responsive means for measuring gas pressure, disposed outside the chamber, attached to and communicating with said tube in pressure-receiving relationship; and means for sweeping away the air in contact with the outer surface of said porous thimble and establishing a layer of uncontaminated air in contact therewith comprising a source of uncontaminated air under pressure, a conduit communicating therewith, a valve adapted to interrupt flow of air disposed in said conduit, and a manifold attached to and communicating with said conduit on the opposite side of said valve from said source of uncontaminated air under pressure, disposed to surround said thimble adjacent to said base and having openings adapted to emit uncontaminated air adjacent the outer surface of said thimble.

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