July 11, 1972 M. J. LUCKEY 3,676,073

ALVEOLAR BREATH VOLUMETRIC ANALYSIS FOR ALCOHOL

Filed May 6, 1970

FIG. 1

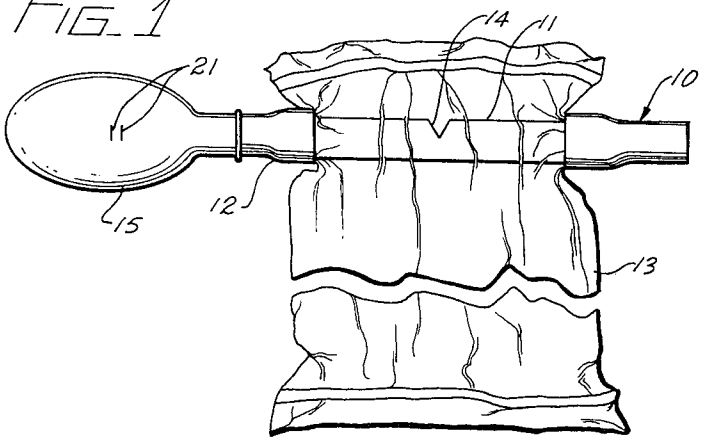


FIG. 2

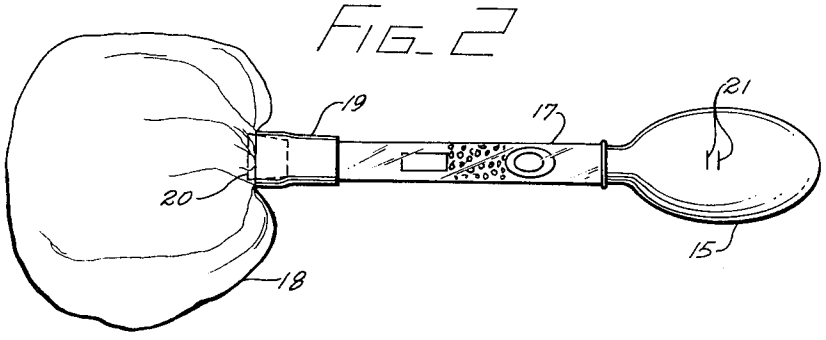


FIG. 5

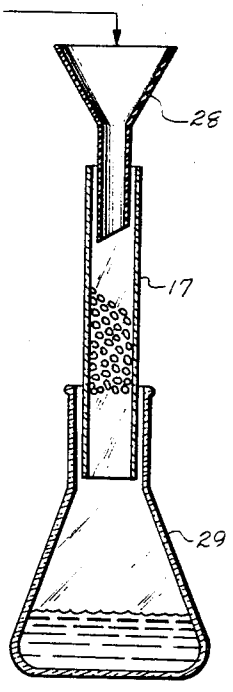


FIG. 3

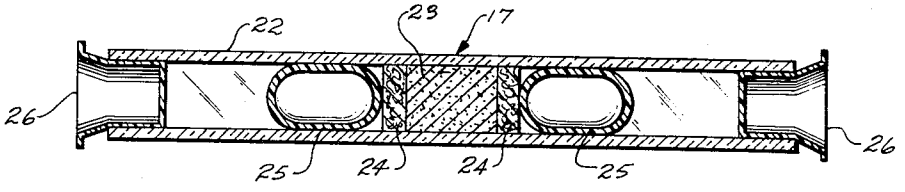
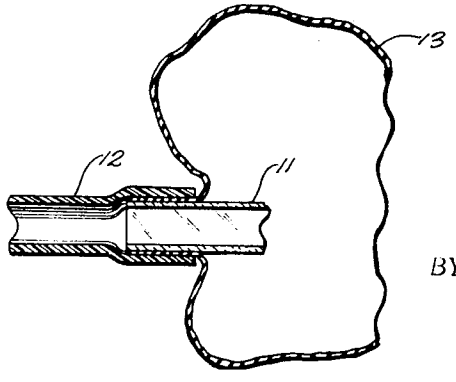


FIG. 4



INVENTOR
MANLEY J. LUCKEY

BY

Christie, Parker & Hale

ATTORNEYS

United States Patent Office 3,676,073 Patented July 11, 1972

3,676,073

ALVEOLAR BREATH VOLUMETRIC ANALYSIS FOR ALCOHOL

Manley J. Luckey, 7252 Osbun Road, San Bernardino, Calif. 92404

Filed May 6, 1970, Ser. No. 35,139
Int. Cl. G01n 33/16
U.S. Cl. 23—232 R 7 Claims

ABSTRACT OF THE DISCLOSURE

A breath sampling kit and method for sampling breath are described for sampling the quantity of alcohol in a fixed quantity of breath without elaborate apparatus. According to this arrangement, a test subject inflates an inelastic bag of predetermined volume connected in bypassing relation to an elastic container such as a balloon. The volume of the bag is such as to accommodate the non-alveolar breath of the test subject. After the bag is filled, the balloon is inflated with the alveolar breath. The balloon is then deflated through a sample tube in which a solid material is contained and inflates a second inelastic bag, the volume of which bears a fixed relation to 1 milliliter of blood so that upon subsequent analysis the quantity of alcohol in the blood is determined directly. The solid material in the tube adsorbs alcohol in the breath and keeps it trapped for later extraction and analysis. The alcohol is extracted from the solid by water or other solvent for alcohol passed through the solid, and the solid material is selected for reversibly adsorbing the alcohol and being substantially insoluble in the extracting solvent so as not to interfere with subsequent analysis, silica gel being particularly preferred.

BACKGROUND

This invention is related to U.S. Pat. 3,437,449 entitled Breath Alcohol Determination by M. J. Luckey, and involves substantial improvements over the invention described and claimed therein.

It is well established that alcoholic intoxication is directly related to blood alcohol content and that the blood alcohol content is determinable by the content of alcohol present in the person's breath derived from the alveolae. The alveolae are the small bulbs in the lung wherein oxygenation of the blood and transfer of impurities from the blood to inhaled air takes place. This invention provides for ready determination of a person's blood alcohol content by accurately extracting the alcohol vapor present in a known volume of alveolar breath. The apparatus is inexpensive and readily adapted for field use so that the person being tested need not be taken to a central testing facility and there is no need for taking blood or urine samples.

There is present in 2,100 milliliters of alveolar breath of the average person, the same weight of alcohol vapor as there is in 1 milliliter of that person's blood. This relation is employed in the present invention to yield a simple effective economical and accurate method and apparatus for rapidly and easily determining the weight percentage of alcohol in the blood of a person being tested.

In other breath alcohol testing, it is often necessary to transport the test subject to a central station in which a breath testing unit is located. This is necesary since the breath testing equipment is relatively expensive and cannot be provided in each and every patrol unit. This is undesirable since in remote areas a long time and distance may be required to reach the testing apparatus and during this time the officer may be out of service. In practice of this invention, there is provided a volumetric technique

for alcohol sampling with a central laboratory determination of the alcohol content with precision. The sampling of the person's breath is, however, done if desired at a remote sampling location for later analysis. The sampling kit is inexpensive and several kits can be carried in each patrol unit.

BRIEF SUMMARY OF THE INVENTION

Thus, in practice of this invention according to a preferred embodiment there is provided a breath sampling kit comprising a first tube connected to an inflatable bag having a fixed volume and to an elastic bag having a variable volume. A second tube having means therein for reversibly absorbing alcohol, and insoluble in solvent for alcohol, is selectably connectable to the elastic bag. The second tube is also connectable to a third inflatable bag having a fixed volume for accumulating a sample from the elastic bag bearing a known relation to a volume of alveolar breath.

A preferred method of employing the sampling kit comprises inflating the first bag for accommodating non-alveolar breath, followed by inflation of the elastic bag to capture alveolar breath. The elastic bag is then deflated through the tube containing the means for reversibly adsorbing alcohol and into the third bag having a fixed volume. The alcohol adsorbed in the second tube is extracted therefrom by a solvent such as water in which the means for adsorbing alcohol is insoluble and the extracted solution is analyzed in a conventional manner to determine alcohol content.

DRAWINGS

Other features and attendant advantages of the present invention will be better understood by reference to the following detailed description of a presently preferred embodiment when considered in connection with the accompanying drawings wherein:

FIG. 1 illustrates means for obtaining an alveolar breath sample after bypassing non-alveolar breath according to principles of this invention;

FIG. 2 illustrates means for extracting alcohol from the breath sample;

FIG. 3 illustrates a sample collection tube;

FIG. 4 illustrates a means for connecting one of the bags which is illustrated in FIG. 1 to a tube; and

FIG. 5 illustrates a technique for extracting alcohol from the tube of FIG. 3.

Throughout the drawings like reference numerals refer to like parts.

DESCRIPTION

FIG. 1 illustrates a portion of breath sampling apparatus constructed according to principles of this invention. As provided in this preferred embodiment, there is a mouthpiece **10** which is preferably made of substantially inert vinyl tubing which is somewhat flexible. Inserted within the tubing forming the mouthpiece **10** is a short length of intermediate tubing **11** which may, for example, be about 2½ inches long. The opposite end of the intermediate tube **11** is inserted into a second short length of vinyl tubing **12** which serves as an outlet. The intermediate tube **11** is preferably made of a relatively rigid material such as, for example, polyethylene, for ready connection to the more flexible tubes **10** and **12** forming the mouthpiece and the outlet respectively.

An inextensible inflatable bag **13**, preferably of sheet polyethylene or the like, is sealed between the mouthpiece **10** and intermediate tube **11** and between the intermediate tube **11** and the exit or outlet tube **12** so that the only communication with the interior of the bag is through the mouthpiece or outlet. A notch or hole **14** in a side of the intermediate tube **11** provides fluid communication from

the interior of this tube to the interior of the bag.

A convenient and inexpensive way of interconnecting the interior tube **11**, bag **13** and outlet tube **12** is illustrated in FIG. 4. According to this arrangement, the intermediate tube **11** is contained within the bag **13** before the latter is heat sealed, and thereafter the inside tube **11** is manually gripped through the flexible walls of the bag **13**, and the end is inserted within the end of the flexible and stretchable vinyl tube **12**. This carries a portion of the wall of the bag **13** between the two tubes so that the bag is tightly gripped therebetween. In addition, there is a shearing action when the two tubes are so assembled, which ruptures the wall of the bag in the region of the end of the tube **11** so that there is fluid communication between the two tubes **11** and **12** having the wall of the bag sandwiched therebetween. If assembly alone does not rupture the wall, a pointed object through the tube **12** will suffice.

This subassembly of the apparatus of this invention is readily and economically made since it is only necessary to cut short lengths of vinyl tubing for the inlet **10** and the outlet **12**, cut a short length of polyethylene tubing **11**, cut, drill or punch a notch or hole **14** in the side of this latter tubing, and insert the piece in an open bag **13** of polyethylene. This latter bag **13** is conveniently made from a length of polyethylene sheet tubing about two inch diameter by heat sealing one end, inserting the piece of tubing **11** and heat sealing the opposite end all in rapid succession. The intermediate tube **11** can then quickly be inserted in the vinyl tubes **10** and **12** to complete the subassembly.

When the subassembly is used, an elastic container **15**, such as an ordinary rubber balloon, is connected to the outlet tube **12**. Thus, when a test subject first blows into the mouthpiece **10**, the balloon **15** may inflate very slightly until an elastic resistance to inflation is encountered. Thereupon, the breath is diverted through the hole **14** so as to inflate the bag **13** until it reaches its final fixed volume. Thereafter, the balloon **15** is inflated against its elastic resistance in its usual manner.

When a person commences to exhale, the first volume of breath is that contained in the nose, mouth, and tracheal and bronchial passages, and this air is not normally in equilibrium with the alcohol content of the blood. The alveolar air, however, is in intimate gas exchange relation with the blood in the alveolae and the alcohol vapor content of the alveolar air is in equilibrium with the alcohol content of the blood. The measurement of alcohol content of the alveolar air is, therefore, an accurate measure of the alcohol content of the blood. It is necessary, however, to avoid the bronchial air in taking a sample since this is not in equilibrium with the blood and would give a fallacious alcohol content.

The bag **13**, therefore, has a fixed volume of about 1,000 milliliters which is sufficient to accommodate all of the air that may be present in the nose, mouth, and tracheal and bronchial passages of a normal person so that the only portion of non-alveolar breath that reaches the balloon **15** is that first small portion needed to inflate the balloon to its rest volume prior to any substantial elastic inflation of the balloon. After the non-alveolar breath is bypassed to the bag **13**, the balloon **15** is then inflated solely with alveolar breath, and when so inflated, the air in the balloon **15** is about 95% alveolar air and 5% non-alveolar air.

After inflation, the balloon **15** is then transferred to a sample tube **17**, as seen in FIG. 2, while the balloon is still inflated. The balloon **15** is then permitted to deflate under the urging of its elastic walls through the sample tube **17** into an inflatable bag **18** having a fixed final volume and made of an inextensible material such as sheet polyethylene. The volume of the inextensible bag **18** is slightly over 2200 milliliters, so that when the breath passes from the balloon **15** through the sample tube **17** to the bag **18**, 2100 milliliters of alveolar breath passes through the sample tube for alcohol extraction. The bag **18** is sealed to a short length of vinyl tubing **19** by a short length of plastic tube **20** inserted therein from the inside of the bag **18** in substantially the same manner the tubing **11** is sealed to the bag **13** and vinyl tubing **12**, as illustrated hereinabove in FIG. 4.

The sample collecting tube **17** is further illustrated in longitudinal cross-section in FIG. 3 and comprises a glass tube **22** within the center of which is positioned a small volume of granular material **23**, hereinafter described in greater detail. A short wad of glass wool **24** is provided at each end of the volume of granular material **23** to prevent it from escaping and a small loop **25** of plastic, such as polyethylene, is pressed into the glass tube **22** to hold the wads of glass wool **24** in position.

The granular material **23** is preferably molecular sieve grade of silica gel such as, for example, grade 28 silica gel available from W. R. Grace Company, Baltimore, Md., in a size range of 20 to 40 mesh. Although silica gel is preferred since it is inexpensive, substantially inert and insoluble in water, and readily absorbs or adsorbs alcohol vapor, other similar molecular sieve materials can be employed so long as they adsorb alcohol vapor from the breath and reversibly release alcohol to an extracting medium. It is preferred that the granular material **23** have a greater affinity for water than for alcohol so that the alcohol vapor adsorbed as breath passes through the granular material is readily released when eluted with water. Silica gel is advantageous since it is also substantially insoluble in alcohols other than ethyl alcohol, hexane, xylene, ketones, aldehydes and the like which may also be used to elute alcohol for analysis.

Previously reactive materials such as magnesium perchlorate have been employed for extracting alcohol vapor from breath. This is not entirely satisfactory, however, since magnesium perchlorate, for example, is soluble in water and the alcohol is removed by dissolving the solid material used to extract alcohol from breath. The dissolved salts must then be removed or otherwise accounted for in chemical analysis since they interfere with accurate determination of alcohol content, particularly if popular spectrophotometric techniques are employed.

As illustrated in FIG. 3, the glass tube **22** is preferably sealed at the ends by plastic plugs **26** both prior to and after use to prevent adsorption of unwanted materials by the silica gel and to prevent loss of alcohol from the silica gel after use.

After a sample has been colletced in the sample tube 17, it is disconnected from the balloon **15** and bag **18** and the plugs **26** are reinstalled in the ends for transport of the sample tube to a laboratory for analysis. The balance of the apparatus is sufficiently inexpensive to be discarded after use. When the sample tube **17** reaches the laboratory, the alcohol is removed from the silica gel by passing a solvent, preferably water, through the gel. As illustarted schematically in FIG. 5, a small funnel **28** is inserted in one end of the sample tube **17** and a small amount of water is poured through to collect in a flask **29**, in which the other end of the sample tube **17** is inserted.

It is generally preferred to elute the alcohol from the silica gel with about two milliliters of water since the concentration of alcohol in the water collected in the flask is then exactly one-half the concentration of alcohol in the blood (since the alcohol is from 2100 ml. of alveolar breath). If desired, however, a greater or lesser quantity of water in the range of from one to ten milliliters can be employed for eluting the alcohol or other solvents, headspace analysis or a hot gas extraction stream can be employed if desired. Once the alcohol is extracted from the silica gel in a solvent, it can be analyzed by any conventional technique well known in the art, such as gravimetric, titrimetric, spectrophotometric, gas chromatographic or the like.

The packing density of the granular material **23** and glass wool **24** varies slightly from sample tube to sample

tube so that the flow rate of gas through the silica gel would vary depending on the pressure applied by the balloon **15**. It is desirable to have a substantially reproducible flow of breath from the balloon **15** through the sample tubes **17** in order that the flow rate is not too high so as to pass breath without opportunity for full absorption of the alcohol vapor. It is also found that the elastic properties of the balloons **15** vary from balloon to balloon.

Therefore, in the process of manufacturing the sample collection kits, it is desirable to measure the flow of gas through each sample collection tube **17** built to determine the flow resistance. The flow resistance is normally within a relatively limited range from tube to tube and the tubes can then be sorted into batches having substantially similar flow resistance. Likewise, the balloons **15** are inflated to a uniform pressure in the course of manufacture in order to sort these according to the pressure applied as they deflate. While the balloon **15** is inflated at a constant pressure during the course of manufacture, a pair of indicia **21** are marked on the side of the balloon at a preselected distance apart. Thereafter, when the balloon is reinflated so that the distance between the marks is again the preselected distance, the balloon pressure is reproduced. Balloons can, therefore, be calibrated to selected inflation pressures for matching with calibrated sample tubes **17** so that a preselected flow rate of gas from the balloon through the sample tube can be reproducibly obtained in each kit. Employing a balloon not only assures a uniform flow pressure through the sample tube but also permits repeated tries to take a sample of a person's breath if he attempts some devious ways of avoiding a sample of alveolar breath. It also provides an opportunity to obtain a full 2100 milliliters of alveolar breath if it is not obtained upon the first exhalation. All that need be done is to prevent air from leaving the partly inflated balloon, compress the inelastic bag **13** to remove air from it, reinflate the inelastic bag **13** to remove non-alveolar breath, and then proceed to further inflate the balloon to obtain a full 2100 milliliter sample.

If desired, duplicate samples can be taken by providing a pair of sample tubes **17** in the kit, and the inextensible bags and balloon can be deflated and reused by the same person.

Although only one embodiment of this invention has been described and illustrated herein, many modifications and variations will be apparent to one skilled in the art. Thus, for example, instead of using a balloon **15** having a single inlet which is successively connected to the sample taking subassembly illustrated in FIG. 1 and the sample retention subassembly illustrated in FIG. 2, a balloon having separate inlet and outlet, and a check valve to prevent reverse gas flow can be employed in the same manner as illustrated in the aforementioned U.S. Pat. 3,437,449. Many other variations and modifications will be apparent to one skilled in the art.

What is claimed is:

1. A method for sampling the blood alcohol content of a person including the steps of:

inflating a flexible inextensible container of preselected volume with a person's breath;

sequentially thereafter and substantially continuously therewith inflating a flexible elastic container with the person's breath so that the elastic container contains a principal proportion of alveolar breath;

passing breath from the elastic container through a vessel including an alcohol vapor extracting medium substantially insoluble in a solvent for alcohol and into a second inelastic container having a preselected volume;

removing extracted alcohol from the medium with a solvent in which the medium is substantially insoluble; and

quantitatively analyzing the solvent for contained alcohol.

2. A method as defined in claim **1** wherein the alcohol vapor extracting medium comprises silica gel.

3. A method as defined in claim **2** wherein the breath is passed through the silica gel at a controlled rate by the steps of:

calibrating the flow resistance of the silica gel;

calibrating the inflation characteristics of the elastically extensible bag; and

matching the flow resistance characteristics and the inflation characteristics to obtain a preselected flow rate.

4. An expendable sampling kit for obtaining a breath sample for alcohol analysis comprising:

a first tube having an end breath inlet and an end outlet and an aperture in a side intermediate the ends;

a first fixed volume inflatable bag sealed to the first tube with the aperture inside the bag;

a second tube having an end inlet and an end outlet;

molecular sieve means in the second tube for adsorbing alcohol from a person's breath and being insoluble in a solvent for alcohol;

an elastically extensible inflatable bag;

means for connecting the elastically extensible bag to the outlet of the first tube and the inlet of the second tube;

a second fixed volume inflatable bag; and

means for connecting the second fixed volume bag to the outlet of the second tube, whereby non-alveolar breath first applied to the end breath inlet of the first tube inflates the first fixed volume bag and alveolar breath sequentially thereafter inflates the elastically extensible bag, breath flows from the elastically extensible bag through the second tube into the second fixed volume bag for exposing a fixed volume of alveolar breath to the molecular sieve means for adsorbing alcohol.

5. A kit as defined in claim **4** wherein the means for adsorbing alcohol comprises granular silica gel.

6. A kit as defined in claim **5** wherein the first tube comprises:

a first piece of substantially rigid tubing having an aperture in one side thereof;

a first piece of flexible tubing having an end surrounding an end of the rigid tubing and having a portion of the wall of the first fixed volume inflatable bag therebetween for sealing the bag to the tube; and

a second piece of flexible tubing having an end surrounding an end of the substantially rigid tubing and having a portion of the wall of the first fixed volume inflatable bag therebetween for sealing the bag to the tube.

7. A kit as defined in claim **5** wherein the gas flow resistance of the contents of the second tube is matched with the elastic properties of the elastically extensible bag for obtaining a preselected gas flow rate therethrough.

References Cited

UNITED STATES PATENTS

3,223,488	12/1965	Luckey	23—254
3,464,186	9/1969	Hankison et al.	55—387 X
3,544,273	12/1970	McConnaughey	23—254

MORRIS O. WOLK, Primary Examiner

R. M. REESE, Assistant Examiner

U.S. Cl. X.R.

23—254 R