

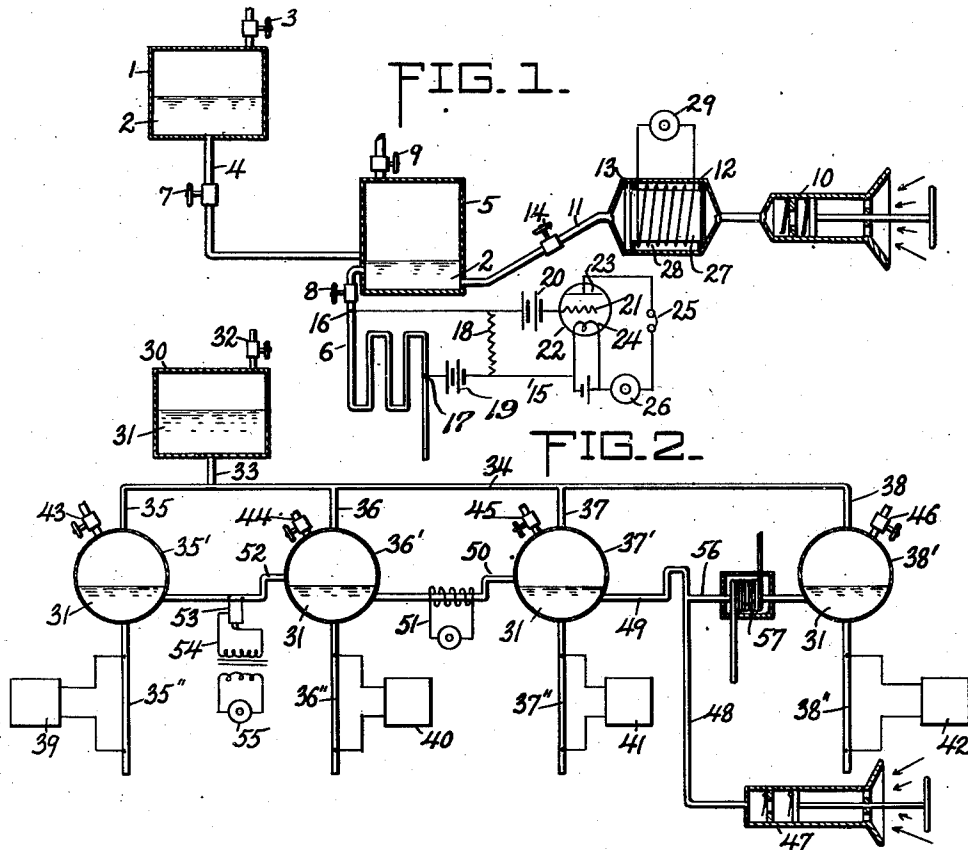
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APPARATUS FOR THE DETECTION AND REMOVAL OF GAS OR GASES

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APPARATUS FOR THE DETECTION AND
REMOVAL OF GAS OR GASES

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My invention relates to an apparatus for detecting the presence of and/or removing toxic gases in and from the ambient atmosphere.

The requirements of military and naval poisonous gas detecting devices are particularly drastic. Doubt as to the kind of gas used and as to its degree of deadliness and persistence imposes a heavy burden on military forces causing them to take extreme precautions and, if they be careless or mistaken in their conclusions, often results in large and unwarranted casualties. A military gas detecting device, if it is to be of any marked utility, must therefore be able to differentiate between persistent and non-persistent agents; and between toxic gases and non-toxic gases used to deceive the enemy as to the intentions of a military commander. Such a device furthermore must be rapid in response and be capable of indicating small concentrations of dangerous gases. This latter feature is of extreme importance since men subjected to one part of mustard gas in a million parts of air for one hour will be casualties. One part of phosgene to two hundred thousand parts of air will kill men in an hour. One part in ten thousand of chlorine will also produce death in an hour. One inhalation of air containing a high concentration of hydrocyanic acid may be fatal. Two parts in a thousand of carbon monoxide for an hour may also be fatal. The concentration of Lewisite necessary to produce a casualty is about the same as mustard gas.

Various means have been employed heretofore for detecting the presence of toxic gases. Spectrum analysis has been utilized by heating the gases in a flame or electric arc, a photo-electric cell serving as an indicating means in the analysis. Such an analysis, however, requires extensive equipment for its performance. A less pretentious and less sensitive means consist in the use of litmus paper which changes in color by reason of the acid nature of these gases. Lethal concentrations, however, may be present before such devices will operate.

The formation of precipitates by chemical composition of the gases with solutions has been used in the past. Of particular note in this connection is the cuprous chloride carbon monoxide precipitate test. Such tests require considerable time for their performance.

The change in electrical conductivity of water or an aqueous solution when carbon dioxide is absorbed therein because of the formation of carbonic acid with attendant ionization has also been used. Due to the low solubility of certain toxic

gases such as, for example, carbon monoxide and certain of the halogen compounds this method has not been practical in their detection.

In carrying out my invention the gas whose presence it is desired to detect is treated in a manner to be described and after treatment is supplied to a medium whose electrical conductivity it is now capable of altering. Any change in electrical conductivity of the medium is noted and thus serves to indicate the presence of the gas. The treatment of the gas may be such as not to change its chemical composition but yet render it capable of altering the electrical conductivity of the medium or it may change the gas to that of a different chemical composition, which latter gas is capable of altering the electrical conductivity of the registering medium. This method of treatment which forms the basis of my invention may also be advantageously employed in the selective detection of a plurality of gases.

With the foregoing preliminary discussion in view, it is an object of my invention to provide an apparatus for detecting the presence of a toxic or non-toxic gas that will not only detect the presence of small concentrations of the same but will detect it quickly and expeditiously.

It is another object of my invention to provide an apparatus which will satisfy the requirements of a military gas detecting apparatus.

It is another and further object of my invention to provide an apparatus which is operable to effectively remove toxic gas or gases from the ambient atmosphere.

It is another and further object of my invention to provide an apparatus for detecting the presence of a plurality of toxic and/or non-toxic gases or the presence of one of a plurality of toxic and/or non-toxic gases that is selective in its operation and which by reason of its selectivity will definitely identify any of the aforesaid gas or gases and advise the observer of their presence.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following description when considered in connection with the accompanying drawing wherein:

Fig. 1 shows diagrammatically one embodiment of my invention for detecting the presence of a gas; and

Fig. 2, a still further embodiment of the instant invention for detecting the presence of and/or removing toxic and/or non-toxic gas or gases and which for this purpose is selective in its operation.

Turning now to Fig. 1 of the drawing there is shown depicted therein at 1 a supply container for the fluid medium 2 whose electrical conductivity is to be altered by any gas or gases absorbed therein. A valve 3 serves as a means for replenishing the fluid 2 in the supply container and a conduit 4 supplies the fluid medium 2 to a second container 5 into which the gas to be analyzed is introduced in a manner which will be explained subsequently. A second conduit 6 of glass or any other suitable insulating material is connected to the container 5 as shown and carries off therefrom the fluid medium 2 which may have been ionized by any gas or gases dissolved therein. It is thus evident that under operating conditions there is a continuous flow of the fluid medium from the container 1 through conduit 4 into the container 5; and from thence through the conduit 6 to a sump tank or other convenient place of discharge. When the apparatus is not in use, flow of any fluid medium from the tanks 1 and 5 is effectively prevented by means of the valves 7 and 8. These valves also serve to adjust the rate of flow of the fluid medium. The conduits 4 and 6 and the rate of flow of the fluid medium are respectively designed and adjusted such that a small quantity of the fluid medium 2 will be in the container 5 at all times in order that as high a concentration of the ionized medium as possible may be obtained with the small amounts of gas forming or contained in the gaseous fluid to be analyzed. A release valve 9 of any suitable design is positioned as shown to assist in the removal of any gas from the container 5 when the pressure thereof reaches a predetermined value. The pressure of the gas in the container 5, however, is not critical and may be determined in any convenient manner as by mounting a conventional pressure gauge on the container.

The fluid medium 2 is chosen such that its electrical conductivity will be altered by the absorption of any gas therein whose presence it is desired to detect. The fluid medium may, for example, be water or a solution of water and alcohol, or any other aqueous solution or convenient medium which changes its resistance upon absorption therein of the gas or gases to be detected.

For supplying the gas or air to be analyzed to the container 5, there is provided a pump 10 of any convenient design and a conduit 11 connecting the pump 10 to the container 5 in the manner shown. This conduit 11 has an enlarged portion 12 for housing a heating unit identified in general by the reference character 13 which will be described more in detail hereinafter. When the valve 14 is in an open position the gas to be analyzed is supplied by the pump 10 through the conduit 11 to the fluid medium 2 within the container 5. The gas so supplied is absorbed in the fluid medium 2 where it increases the electrical conductivity of the said medium.

Any increase in electrical conductivity of the fluid medium is detected by an amplifying indicator unit which is identified in general by the reference character 15. This unit includes two electrodes 16 and 17 which are positioned within the insulating conduit 6 in the manner shown. Thus short circuiting of the electrodes by the conduit is effectively prevented. For most efficient operating conditions the amount of the fluid medium 2 between the electrodes 16 and 17 should be as small as possible but the elec-

trodes should be spaced as far apart as practicable. The electrodes 16 and 17 are connected to the ends of a resistance 18 of suitable value, any convenient source of electromotive force 19 being interposed between the electrode 17 and the resistance 18 as shown. A second source of electromotive force 20 of suitable value serves to impress a negative bias on the grid 21 of the space discharge device 22. To the anode 23 and thermionic cathode 24 of this device there are connected a pair of ear phones 25 and an alternating source of electromotive force 26. If now the electrical conductivity of the fluid medium 2 is increased due to the absorption of any gas therein there will be a current flow or an increase in current flow through the resistance 18. This will have the effect of decreasing the negative bias impressed upon the grid 21 and will result in either a current flow in the plate circuit or an increase of current flow therein. Any current flow in the plate circuit is detected by the ear phones which will present to the operator an intermittent audible sound. While I have shown for illustrative purposes a pair of ear phones in the plate circuit to serve as a detecting or indicating means I do not desire to be restricted thereto. It is within the purview of my invention to employ any suitable indicating means known to the prior art in the plate circuit and any suitable source of electromotive force for energizing the same. Thus, for example, instead of the ear phones 25 there could be conveniently substituted therefor a milliammeter and for the alternating current source of electromotive force 26 a direct source of electromotive force.

Toxic and non-toxic gases are not often in a state such that they can be readily absorbed by fluid mediums such, for example, as water. It is usually possible to treat these gases, however, so that they are capable of being readily absorbed with attendant hydrolysis by the application of radiant energy which may be in the form of heat or light. Thus, mustard gas decomposes readily at above 150° C.; and carbon monoxide gas combines with the oxygen of the ambient atmosphere to form carbon dioxide at a somewhat higher temperature.

For treating the gas to be analyzed such that the gas either in its original or chemically altered state may be readily soluble in a fluid medium in which it would otherwise not be soluble, I have provided a heating unit 13 to which brief reference was made hereinbefore. This heating unit includes a porous, heat refractory but heat conducting member 27 of glass, for example, suitably supported in the enlarged portion 12 of the conduit 11 and surrounded by a resistance coil 28 which in turn is energized by any convenient source of electromotive force 29. It will be observed that the refractory member 27 in addition to its porosity is of substantial mass. This construction has been made necessary due to the fact that the time of passage of the gas through the heating zone is necessarily brief and by making the member 27 porous and of substantial mass the proper heating of the gas is thereby insured.

The design of the heating unit may be better understood by considering the amount of heat it would have to supply in order to heat a predetermined quantity of air to a hydrolyzing temperature or temperature of chemical decomposition of the gas to be tested. Let it be assumed that one liter of air containing one millionth

part of mustard gas and considerable water vapor is to be forced into the apparatus per second by the pump 10. Since one liter of air weighs 1.293 grams and the specific heat of air is 0.242 it will require a little more than 0.3 calory to raise the temperature of this liter of air 1° C. If the air is pumped into the apparatus at an ambient temperature of 30° C. and it is desired to raise the temperature of the air to above 150° C. in order to effect hydrolyzation of the mustard gas in the fluid medium 2, at least 37.5 calories of heat are required from the heating unit 13 each second. Since one watt generates 0.24 calory per second it will be necessary for the heating unit to have a power rating of at least 150 watts. If, now the source of electromotive force 29 is assumed to have a value of 100 volts, the resistance 28 can be no greater than 66⅔ ohms if the current through the resistance is to be 1.5 amperes. Under certain circumstances this amount of power, namely 150 watts, may not be available in the field. Where this is the case a flame or any other heating means known to the prior art may be used to impart to the refractory member 27. If now one liter of air is forced through this apparatus per second the weight of the air in 100 seconds would be 129.3 grams and the weight of the mustard gas would be 0.000129 gram. Such a quantity of hydrolyzed or chemically decomposed mustard gas would produce marked changes in the electrical conductivity of the fluid medium 2, which change would be readily detectable by the amplifying indicator unit 15.

For illustrating the mode of operation of my apparatus it will be assumed that the atmosphere to be analyzed is free from carbon dioxide but contains, unknown to the operator, mustard gas. Such conditions, for example, might obtain in a mustard gas factory where it becomes necessary to furnish suitable gas detecting means to insure the safety of the operating personnel. Before supplying the atmosphere to the apparatus for analysis the valves 7 and 8 are adjusted so that a predetermined flow of the fluid medium 2 from the container 1 through the conduit 4, container 5 and conduit 6 is established. With a continuous flow of the fluid medium 2 it is possible to analyze portions of the atmosphere from time to time and also make certain that the fluid medium 2 with any absorbed gas is supplied to the conduit 6 for detecting operations. The temperature of the ambient atmosphere is next ascertained so that the operator will know what value of current it will be necessary to supply to the resistance coil 28 so that any mustard gas in the atmosphere will be heated to its hydrolyzation or decomposition temperature. After adjusting the source of electromotive force 29 to a value such that it will cause the necessary current to flow through the resistance 28 the pump 10 is set in operation. The mustard gas in the atmosphere as it is forced through the porous member 27 is heated to its hydrolyzation temperature and enters into the fluid medium 2, which may be water, where it is absorbed. The absorption of this gas causes an increase in the electrical conductivity of the medium 2 which, when a column thereof is interposed between the electrodes 16 and 17, results in a current flow or an increase in current flow through the resistance 18. This in turn causes a decrease in the negative bias impressed on the grid 21 with attendant current flow or increase in current flow in the plate circuit of the space discharge device 22. The earphones 25 thereupon advise the op-

erator of the change in electrical conductivity of the fluid medium 2 and thus detect the presence of the mustard gas.

For detecting the presence of carbon monoxide in the atmosphere the portion thereof to be analyzed is first freed from any carbon dioxide. This may be accomplished in any suitable manner, as by passing the portion of the atmosphere under analysis through a solution of lime water. The heating unit 13 is readjusted such that it will furnish a temperature sufficient to convert any carbon monoxide in the atmosphere to carbon dioxide which is soluble in the medium 2. The atmosphere free from any carbon dioxide is then supplied to the apparatus in the manner previously described herein and the carbon monoxide converted to carbon dioxide which is then passed into solution with the fluid medium 2. The change of electrical conductivity attending the absorption of this gas is then detected by the amplifying indicator unit 15 in a manner previously described to thus advise the operator of the presence of carbon monoxide in the ambient atmosphere.

A large number of gases of low toxicity such as carbon dioxide, ammonia and low but harmless concentrations of chlorine will operate the apparatus of Fig. 1. Hence, it is desirable under certain circumstances to first filter out harmless gases or gases present in harmless concentrations before applying the toxic gas to the medium whose electrical conductivity is to be altered by the absorption thereof. Some of the highly toxic gases such as, for example, Lewisite hydrolyze readily. Furthermore, the melting points of these gases are usually much higher than those of the non-toxic gases and consequently their vapor pressures are extremely low at low temperatures. Thus, Lewisite melts at approximately -18° C., chlorine at -102° C., while carbon dioxide melts at even a lower temperature.

In Fig. 2 there is illustrated an apparatus which utilizes the foregoing properties of certain of the toxic gases to selectively operate one or more of a plurality of indicator units depending upon the nature of the gas supplied to the apparatus for analysis. In this figure the reference character 30 identifies the supply container for the fluid medium 31 whose electrical conductivity is to be altered by the absorption of a gas or gases to be analyzed. This fluid is supplied to the container 30 by means of a valve 32 and is conveyed by the conduit 33 to the main supply conduit 34. Branch conduits 35, 36, 37 and 38 extend from the main supply conduit 34 to their respective containers 35', 36', 37' and 38'. The fluid 31 after passage through the containers 35', 36', 37', 38' is carried off to a suitable sump tank or other convenient point by means of the conduits 35'', 36'', 37'' and 38''. Any change in the electrical conductivity of the fluid medium 31 is detected by amplifying indicator units 39, 40, 41 and 42 associated respectively with the conduits 35'', 36'', 37'' and 38''. Each of these conduits, as is the embodiment of Fig. 1, is made of glass or any other suitable insulating material to prevent the short circuiting of the indicator electrodes by the conduit. These amplifying indicator units are identical in construction with the one previously described and depicted in Fig. 1. It is to be observed, however, that any other means may be employed to indicate any change in the electrical conductivity of the fluid medium 31. In order to avoid the building up of any excessive gas pressure within the

containers 35', 36', 37' and 38' these containers are provided respectively with release valves 43, 44, 45 and 46. Incidentally, the valve 43 may also serve to supply the gaseous fluid for breathing purposes after all toxic constituents have been removed therefrom.

The fluid medium 31 here used is water but it is evident that a solution of water and alcohol, any other aqueous solution or any convenient medium may be employed which have the property of changing their electrical conductivity upon the absorption of any gas therein. A pump 47 of any convenient design supplies a portion of the ambient atmosphere to be analyzed to the various containers of the apparatus by means of the conduit 48. A portion of this atmosphere proceeds via the conduit 49 into the container 37' beneath the surface of the fluid medium 31. The fluid medium or water 31 filters out those gases which hydrolyze readily therein such as ammonia, chlorine, carbon dioxide and Lewisite and permits the mustard gas and the carbon monoxide to pass therethrough. Any variation in the electrical conductivity of the fluid medium 31 within the container 37' is indicated by the amplifying unit 41. It is to be observed at this point that liquids other than water may be used where it is desired to filter out other gases. The atmospheric constituents, namely oxygen, mustard gas and carbon monoxide, which are not absorbed by the fluid medium in the container 37' proceed therefrom and enter the conduit 50. Before passing into contact with the fluid medium 31 in the container 36', however, these constituents are heated to the hydrolyzation temperature of mustard gas by means of any suitable heating unit 51 which may, for example, be identical with that shown in Fig. 1. Since the gaseous constituents within the conduit 50 have been heated to the hydrolyzation temperature of mustard gas, namely to a temperature above 150° C., any mustard gas if present will be absorbed by the fluid medium 31 within the container 36' while any oxygen or carbon monoxide will enter the conduit 52. For heating the carbon monoxide to a temperature such that it will be converted to carbon dioxide in the presence of the oxygen, I have shown for illustrative purposes a spark plug 53, the electrodes of which are positioned within the conduit 52 and which are energized by the secondary of a transformer 54, whose primary in turn is energized by an alternating source of electromotive force 55. The carbon monoxide gas is ignited by the spark across the spark gap of the spark plug and changed to carbon dioxide which in turn is dissolved in the liquid 31 of the container 35', any change in electrical conductivity of which is detected by the amplifying unit 39. The ambient atmosphere, after the filtration steps described, may be supplied by the valve 43 for breathing purposes if desired.

Simultaneously, with the passage of a portion of the ambient atmosphere through the conduit 49 into the container 37' another portion of the atmosphere enters the branch conduit 56. A refrigerating unit including a coil 57 through which there is passed any suitable refrigerant known to the prior art and surrounding the conduit 56 serves to cool the gaseous fluid in the conduit to a temperature at which any Lewisite gas, if present therein, will condense. Any chlorine, ammonia, and carbon dioxide if present in the gaseous fluid, however, pass through the conduit 56 and into contact with the fluid medium

31 in the container 38' where they change the electrical conductivity of the medium 31 which in turn is noted by the amplifying indicator unit 42.

That the foregoing apparatus will give a selective indication of the gases present in the ambient atmosphere will now be demonstrated. If the indicator unit 39 operates but the units 40, 41 and 42 do not the ambient atmosphere contains a gas which hydrolyzes at a temperature necessary to convert carbon monoxide to carbon dioxide. The unknown gas must therefore be carbon monoxide. If, on the other hand, the indicator unit 40 operates to the exclusion of all other indicator units the unknown gas must be mustard gas. If the units 41 and 42 alone operate and give equal indications the gas or gases present are those of the low toxic group. If, on the other hand, 41 operates to the exclusion of all other units or if 41 and 42 operate to the exclusion of all other units but give unequal indications then it is known that Lewisite is present in the ambient atmosphere.

By forcing large quantities of the gaseous medium to be analyzed through the apparatus it is possible to indicate extremely small concentrations of toxic and/or non-toxic gases. While the foregoing embodiments of my invention employ among other detecting mediums, a fluid medium such as water, it is to be emphasized that any other fluid detecting medium may be employed so long as it has the property of changing its resistance attending the absorption of any gas or gases therein.

According to the provisions of the patent statutes I have set forth the principle and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiments. However, I desire to have it understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically illustrated and described.

The invention herein described and claimed may be used and/or manufactured by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

I claim:

1. A method of detecting the presence of mustard gas in a gaseous mixture which comprises the steps of heating the gas mixture to the hydrolyzation temperature of mustard gas, passing the mixture in its heated state into solution with an aqueous medium whose electrical conductivity is altered thereby, and noting any change in the electrical conductivity of the said medium to thereby detect the presence of the gas.

2. In an apparatus for detecting the presence of any Lewisite, mustard gas, or carbon monoxide in an ambient atmosphere, in combination, a conduit supply means for introducing said atmosphere into the apparatus, a first closed absorbing vessel arranged to contact a gas with a liquid absorbent therein, first conduit means connected with said conduit supply means and with a lower portion of said first vessel, cooling means associated with said first conduit means, a second, a third, and a fourth similar closed absorbing vessel, each arranged to contact a gas with a liquid absorbent therein, a second conduit means connected with said conduit supply means and with a lower portion of said second vessel, a third conduit means connecting an upper portion

of said second vessel and a lower portion of said third vessel, heating means associated with said third conduit means, a fourth conduit means connecting an upper portion of said third vessel and a lower portion of said fourth vessel, electrical spark-producing means incorporated in said fourth conduit means, individual means connected to each of said four vessels and arranged to drain a portion of said absorbent therefrom while maintaining a body of liquid in said vessels, and indicating means associated with each of said individual liquid draining means for indicating relative electrical conductivity of the liquid drained therethrough.

3. In an apparatus for detecting the presence of a toxic gas in the ambient atmosphere, in combination, a conduit supply means for introducing said atmosphere into the apparatus, a first closed absorbing vessel arranged to contact a gas with a liquid absorbent therein, conduit means connected with said conduit supply means and with a lower portion of said first vessel, cooling means associated with said conduit means, a second closed absorbing vessel arranged to contact a gas with a liquid absorbent therein, a second conduit means connected with said conduit supply means and with a lower portion of said second vessel, individual means connected to said first and second vessels and arranged to drain a portion of the absorbent therefrom while maintaining a body of liquid absorbent in each of said vessels, and indicating means associated with each of said individual means for indicating relative conductivity of the liquid drained therethrough.

4. In an apparatus for detecting the presence of any mustard gas or carbon monoxide in the ambient atmosphere, in combination, a conduit supply means for introducing said atmosphere into the apparatus, a first closed absorbing vessel arranged to contact a gas with a liquid absorbent therein, connected at a lower portion thereof to said conduit supply means, a second similar closed absorbing vessel, conduit means connecting an upper portion of said first vessel and a lower portion of said second vessel, heating means associated with said conduit means, a third similar closed absorbing vessel, conduit means connecting an upper portion of the second vessel with a lower portion of the third vessel, heating means associated with said last named conduit means, individual means connected to the second and third vessels arranged to drain a portion of said absorbent therefrom while main-

taining a body of liquid in said second and third vessels, and indicating means associated with each liquid draining means for indicating relative electrical conductivity of the liquid drained therethrough.

5. In an apparatus for detecting the presence of at least two gases in the ambient atmosphere, in combination, a conduit supply means for introducing said atmosphere into the apparatus, a first closed absorbing vessel arranged to contact a gas with a liquid absorbent, connected at a lower portion thereof to said conduit supply means, a second similar closed absorbing vessel, first conduit means connecting an upper portion of said first vessel and a lower portion of said second vessel, heating means associated with said first conduit means, a third similar closed absorbing vessel, second conduit means connecting an upper portion of said second vessel with a lower portion of said third vessel, spark-producing means incorporated in said second conduit means, individual means connected to said second and third vessels arranged to drain a portion of said absorbent therefrom while maintaining a body of liquid in said second and third vessels, and indicating means associated with each said individual liquid draining means for indicating relative electrical conductivity of the liquid drained therethrough.

6. In an apparatus for detecting the presence of toxic gases in the ambient atmosphere, in combination, a conduit supply means for introducing said atmosphere into the apparatus, a first closed absorbing vessel arranged to contact a gas with a liquid absorbent therein, a first conduit connecting said conduit supply means with a lower portion of said first vessel, cooling means associated with said first conduit, a second similar closed absorbing vessel, a second conduit connecting said conduit supply means to a lower portion of said second vessel, a third similar closed absorbing vessel, a third conduit connecting the upper portion of said second vessel to the lower portion of said third vessel, heating means associated with said third conduit, individual means connected to each of said three vessels and arranged to drain a portion of the liquid absorbent therefrom while maintaining a body of said absorbent therein, and indicating means associated with each said individual draining means for indicating relative electrical conductivity of the liquid drained therethrough.

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