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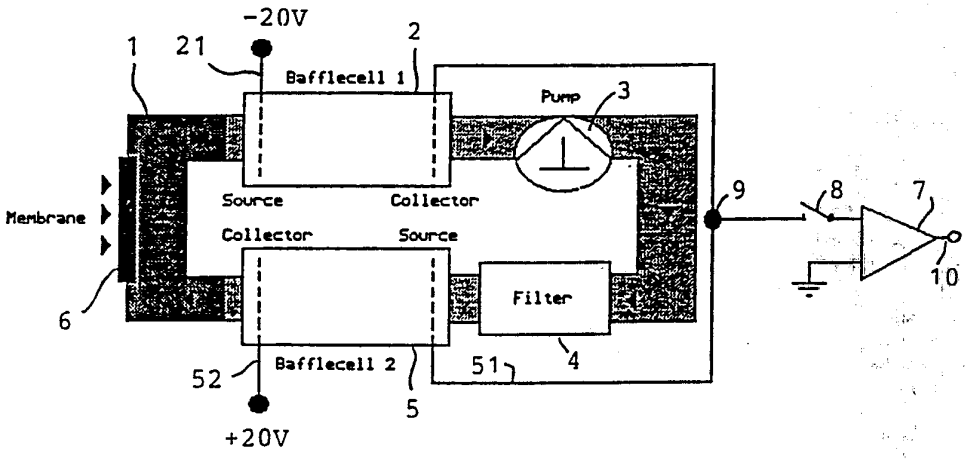
(54) Title: GAS DETECTOR




(57) Abstract

A trace gas detector comprises in a closed gas loop (1) two baffle cells (2, 5) with an intermediate trace gas filter (4). Each baffle cell consists of an ionization source (21, 51), a labyrinth-like recombination zone and of a collector electrode (22, 52). A differential circuit (7, 9) derives a differential signal from the two output signals of the two baffle cells. This differential signal only depends on the trace gas concentration. Temperature changes and supply voltage changes are compensated by means of the differential circuit.

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# Gas Detector

The invention relates to an apparatus for detecting the loading of a carrier gas with small concentrations of trace gases, in particular the loading of air with war gases. The invention for this purpose uses an apparatus where a gas mixture containing said trace gases flows through a labyrinth cell comprising a radiation source for ionizing the gas molecules, a recombination zone consisting of baffles or similar devices for labyrinth-like increasing the length of the flow path, and a collector electrode at the outlet of said recombination zone. An apparatus of this type is known from U.S. patent 38 35 328. Further improvements of this ionization detector are described in U.S. patents 40 57 550, 42 38 698 and 43 62 941. In all those known baffle cells an airstream is generated through the cell by means of a ventilator or a pump. At the input of the cell an ionization means such as a radiation source is provided and the gas stream flows through a flow path, the length of which is increased in the form of a labyrinth. Within this labyrinth path most of the ionized carrier gas molecules recombine, whereat the trace gases together with ions of the carrier gas form molecule packets or clusters which do not recombine within said labyrinth. These clusters rather move to the collector electrode and there generate a corresponding electrical current.

Problems arise if the trace gas such as mustard gas is present only in very small concentrations and therefor the generated electrical currents are only available in the range of $10^{-12}$A ($10^{-12}$A = 1pA). In those cases the measuring signal might be covered by the noise of the subsequent amplifier. Furthermore, one cannot be sure that all ionized carrier gas molecules really recombine so that by non-recombined carrier gas molecules a further interference signal may be generated. Particular difficulties arise if the detector has to be used in a large temperature range such as from -30°C to +50°C and is expected to measure accurately over the entire range. Furthermore, it is desired that changes of the supply voltage or any external electromagnetic radiation should not influence the measuring result.

It is the object of the invention to disclose a trace gas detector, in particular a LOST detector whose accuracy and reliability is not impaired by internal interference such as non-recombined carrier gas ions or a remainder of water vapor, nor is impaired by external interferences such as temperature changes, changes of the supply voltages or by external electromagnetic radiation. These and other objects are achieved by a detecting apparatus according to claim 1, whereat said labyrinth cell as a first labyrinth cell together with a filter for the trace gases to be detected, a gas flow generating means, and with a second labyrinth cell provided

downstream of said filter forms a closed gas loop. Whereat further the output signals of the first labyrinth cell through which the gas mixture flows and the output signals of the second labyrinth cell through which the filtered gas stream flows are electrically compared by a differential circuit, and where at the output of said differential circuit a signal is available corresponding to the concentration of the trace gas to be detected. The labyrinth or baffle cell located in the closed gas loop in front of the filter and/or in front of the drying means delivers an output current which depends on the trace gas to be detected as well as on eventual internal interference influences. However, the baffle cell detector behind the filter and/or the drying means responds only to those interference influences. Forming the difference of the two output signals removes the influence of those internal and external interferences so that the differential output signal depends only on the concentration of the trace gas.

A further problem arises during the detection of blister agents, in particular sulfur-LOST (mustard gas $S(CH_2CH_2)_2CL_2$) and nitrogen-LOST ($N(CH_2CH_2Cl)_3$) insofar as a high concentration of water vapor impedes the formation of trace gas clusters. This problem can be solved in that according to a further improvement of the invention the gas mixture is fed to the closed gas loop via a water vapor barrier such as a silicon diaphragm. This closed gas loop then

only contains a very small remainder of water vapor which in addition by means of a dryer can be stabilized to a dew point smaller than 30°C. Such dryer simultaneously works as a filter or can be combined with an active charcoal filter. Further preferred modifications of the invention are described in the dependent claims. The invention discloses a compact trace gas detector which doesn't need high voltage but can be operated from low voltage batteries. Said detector in view of its small power consumption and small dimensions can be combined with another detector responsive to other war gases, such as nerve agents, into a compact universal detector. A suitable nerve agent detector comprising a so-called dynamic grid cell is described in U.S. patent 47 75 795.

The invention will now be described with reference to a preferred embodiment shown in the drawing. In this drawing

Fig. 1 shows an example for a blister agent detector comprising a closed gas loop in accordance with the invention, and

Fig. 2 shows the combination of such detector with two further detectors into a single compact universal war gas detector unit, whereat a second detector comprises a dynamic grid cell for nerve agent detection and the third detector is an electrochemical cell for the detection of shocking agents.

Figure 1 shows a closed loop gas channel 1 in which a first baffle cell 2, a pump 3, a filter 4 and a second baffle cell

5 are positioned one behind the other. The gas which has to be investigated is supplied into this gas channel 1 via a water vapor barrier formed by a diaphragm 6. The two baffle cells 2 and 5 may have the structure as known from U.S. patent 38 35 328. Each of them comprises a source electrode 21 and 51, respectively, and a collector electrode 22 and 52, respectively. For ionizing the gas molecules flowing through the cell and therewith for forming gas clusters enriched with molecules of the trace gases, each of the two baffle cells 2 and 5 comprises a radioactive radiation source, e.g. a foil coated with the radioactive element Americium 241. The carrier gas (air) ions recombine during their flow through the labyrinth path of the cells. However, negative clusters enriched with blister agents do not recombine. These clusters rather move through cell 2 and generate a current at its collector 22. Filter 4 removes all trace gas portions from the gas stream and for this purpose may be an active charcoal filter. Simultaneously this filter comprises a dryer in order to remove remaining water vapor molecules from the gas loop. Therefore, an ionized trace gas-free carrier gas flows through cell 5. The electrical signal generated at collector electrode 52 therefor only depends on the flow of carrier gas ions. The formation of a differential signal derived from the output signals of both cells 2 and 5 is achieved by connecting together at junction 9 the collector electrode 22 of the first baffle cell 2 and the source electrode 51 of the second baffle cell 5. Junction 9 is connected to the input of preamplifier 7. A switch 8 periodically interrupts the differential current and during the current pauses the differential amplifier works

with open or grounded input and therewith by means of a control circuit can be automatically adjusted and balanced. All noise or interference caused by temperature changes of the gas or of the measuring apparatus or caused by changes of the supply voltage at the two baffle cells or by changes of the speed of the pump will effect the output signals of both baffle cells in the same sense and amount and therefore are compensated by the difference-forming circuit. Both baffle cells 2 and 5 are chosen such that their characteristic values correspond to each other. The measuring apparatus may be balanced or adjusted by first feeding the apparatus with a carrier gas which does not comprise any trace gases, and at the output 10 of the amplifier 7 the subsequent measuring circuit is balanced such that it in this case shows a zero output signal (no trace gases). The source electrode 21 of the first baffle cell 2 and the collector electrode 52 of the second baffle cell 5 are connected to voltages (-20V and +20V, respectively) of identical amplitude but opposite polarity.

The combined war gas detector shown in Figure 2 includes in its lower portion the blister agent detector as described above with reference to Figure 1. This is a module of the entire detecting apparatus and is coupled to the flow path 40 of a further detector via diaphragm 6. This diaphragm 6 is provided between a membrane holder 61 of the blister agent detector and a membrane holder 62 of the second flow path 40. The second detector comprises between its gas inlet 41 and the aforementioned membrane holder 62 a second detector module comprising a particle filter 42, a dynamic grid cell 43 and a

temperature sensor 44. An example of such a second detector responsive to shocking agents is known from U.S. patent 47 75 795. The gas flow through the dynamic grid cell 43 is accomplished by a ventilator or a pump 45. An electrochemical cell 47 is provided between said pump and the gas outlet 46. This electrochemical cell 47 may be used for the detection of shocking agents. The structure of this electrochemical cell 47 is not part of this invention. The block diagram according to Figure 2 further shows that here three filter modules are combined to a compact war gas detector with these three modules responding to all presently known war gases. None of the ionizing cells 43, 2 and 5 requires a high voltage supply and for detecting the various war gases no chemicals must be supplied, monitored and disposed. The principle of the present invention, namely using two measuring cells connected via a filter into a closed gas loop and forming the difference of the output signals, cannot only be used for detecting mustard gas or other war agents, but may also be used for detecting other trace gases.

Claims:

1. Apparatus for detecting trace gases contained in a gas mixture such as air, with said gas mixture flowing through a labyrinth cell comprising

a radiation source for ionizing the gas molecules;

a recombination zone consisting of baffles or similar devices for labyrinth-like increasing the length of the flow path;

and a collector electrode at the outlet of said recombination zone;

c h a r a c t e r i z e d i n t h a t

a) said labyrinth cell (2) as a first labyrinth cell together with

a1) a filter (4) for the trace gases to be detected,

a2) a gas flow generating means (3), and with

a3) a second labyrinth cell (5) provided downstream of said filter

forms a closed gas loop (1);

b) the output signals of the first labyrinth cell (2) through which the gas mixture flows and the output signals of the second labyrinth cell (5) through which the filtered gas stream flows are electrically compared by a differential circuit (7, 9); and

c) at the output (10) of said differential circuit a signal is available corresponding to the concentration of the trace gas to be detected.

2. The apparatus according to claim 1 in which each labyrinth cell (2, 5) comprises a source electrode (21, 51) and a

collector electrode (22, 52), c h a r a c t e r i z e d i n t h a t the source electrode (21) of the first labyrinth cell (2) and the collector electrode (52) of the second labyrinth cell (5) are connected to supply voltages having identical amplitudes but being of opposite polarity;
and that the collector electrode (22) of the first labyrinth cell (2) and the source electrode (51) of the second labyrinth cell (5) are connected together (at 9) and are connected to the input of a preamplifier (7) for the differential signal.

3. The apparatus according to claim 1 or 2, c h a r a c - t e r i z e d i n t h a t the trace gas filter (4) comprises a gas drying means.

4. The apparatus according to one of the claims 1 to 3, c h a r a c t e r i z e d i n t h a t at the inlet of the closed gas loop (1) in front of the first labyrinth cell (2) a diaphragm filter (6) is provided for preventing water vapor from entering said closed gas loop.

5. The apparatus according to claim 4, c h a r a c t e r - i z e d i n t h a t said diaphragm (6) on its side opposite the closed gas loop (1) is exposed to the gas stream of another measuring system (40 - 45) which is sensitive to at least one different trace gas.

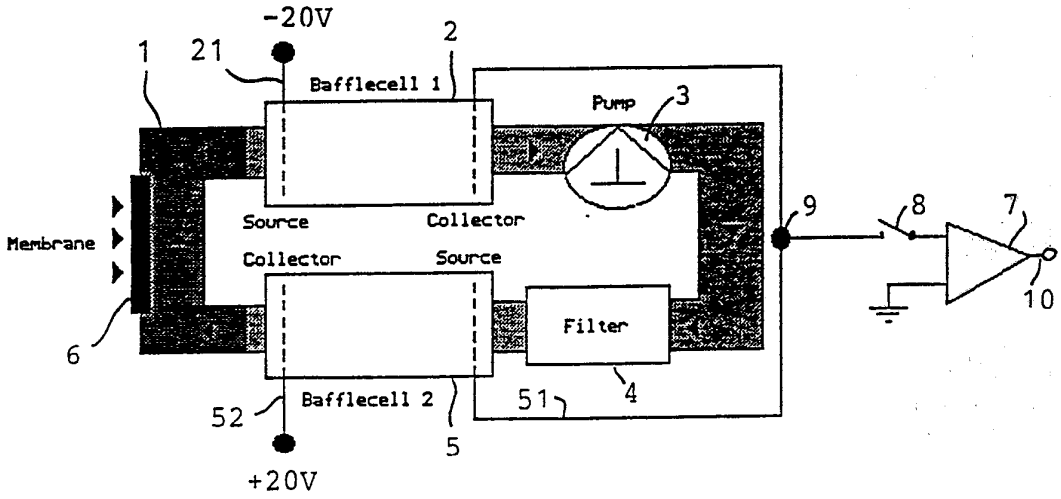
6. The apparatus according to claim 5, c h a r a c t e r-

i z e d i n t h a t said other measuring system responsive to a different trace gas comprises a grid cell (43) for ion mobility spectroscopy and said diaphragm (6) is exposed to the gas stream downstream of said grid cell (43).

7. The apparatus according to claim 6, c h a r a c t e r - i z e d i n t h a t a second gas flow generating means (45), such as a pump or a ventilator, is provided within the gas path (40) of the gas flow through the other trace gas measuring system (40 to 45).

8. The apparatus according to claim 7, c h a r a c t e r - i z e d i n t h a t a further measuring cell (47) is provided downstream of the second gas flow generating means (45), said further measuring cell being responsive to a third type of trace gases and in particular being an electrochemical measuring cell.

Fig. 1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21
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Baffelcell 1
Pump
3
Source
Collector
Membrane
Collector
Source
9
8
7
10
Filter
6
4
52
Baffelcell 2
51
5
+20V

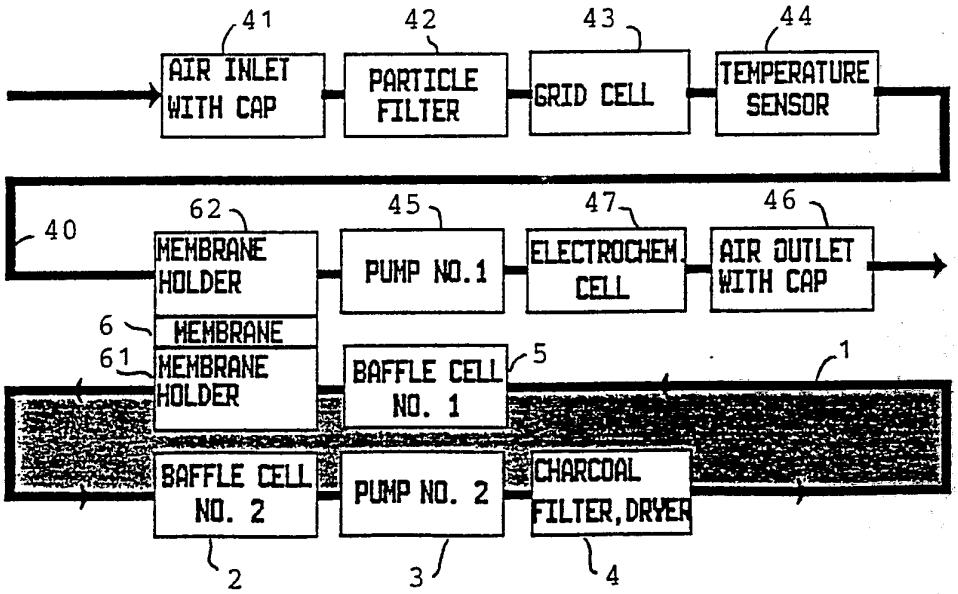
41
42
43
44
AIR INLET WITH CAP
PARTICLE FILTER
GRID CELL
TEMPERATURE SENSOR
40
62
45
47
46
MEMBRANE HOLDER
PUMP NO.1
ELECTROCHEM CELL
AIR OUTLET WITH CAP
6
MEMBRANE
61
MEMBRANE HOLDER
BAFFLE CELL NO. 1
5
1
BAFFLE CELL NO. 2
PUMP NO. 2
CHARCOAL FILTER, DRYER
2
3
4

Fig. 2

# INTERNATIONAL SEARCH REPORT

International Application No PCT/EP 90/00195

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 01 N 33/00, G 01 N 27/66

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

| Classification System | Classification Symbols |
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| IPC[5] | G 01 N |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

| Category [10] | Citation of Document, [11] with indication, where appropriate, of the relevant passages [12] | Relevant to Claim No. [13] |
|---|---|---|
| Y | US, A, 3558283 (W.R. FREEMAN) 26 January 1971 see figures 1,2 -- | 1,2 |
| Y | EP, A, 0233579 (K.E. BIEHL) 26 August 1987 see front page (cited in the application) -- | 1,2 |
| A | US, A, 3997297 (A. JENKINS) 14 December 1976 see front page -- | 1 |
| A | GB, A, 2155185 (J. STETTER) 18 September 1985 see front page -- | 1 |

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IV. CERTIFICATION

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III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)

| Category * | Citation of Document, [11] with indication, where appropriate, of the relevant passages | Relevant to Claim No. |
|---|---|---|
| A | US, A, 3620931 (P. REICHNER)<br>16 November 1971<br>see figure 2 | 1 |

# ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO. EP 9000195 SA 33966

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 07/06/90
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| Patent document cited in search report | Publication date | Patent family member(s) | | Publication date |
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| EP-A- 0233579 | 26-08-87 | DE-A- | 3604893 | 20-08-87 |
| | | CA-A- | 1245377 | 22-11-88 |
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| US-A- 3997297 | 14-12-76 | None | | |
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