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(54) **Title:** DEHUMIDIFYING AND PURIFYING SYSTEM FOR AIR SERVING AS CARRIER GAS IN CONTAMINATION INDICATORS

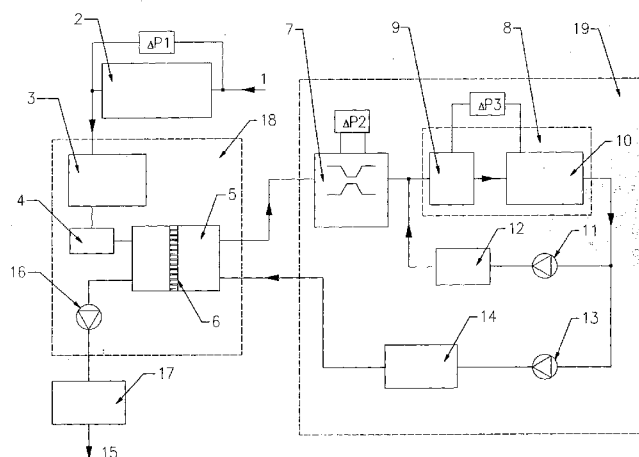


Fig. 1

(57) **Abstract:** The solution, according to the invention, has a number of advantages. Namely, with two internal circuits in two-stage dehumidifying systems, this significantly reduces the humidity of air drawn for analysis, practically without reducing the concentration of the tested substance, which allows very effective detection of various substances (in low concentrations at the device inlet). The dehumidifying and purifying system for air serving as carrier gas in contamination indicators is characterised in that the outlet of gas from the chamber (8) is connected in parallel with the inlet of gas to the chamber and with the outlet of gas from the system, whereby, between the outlet from and inlet to the chamber, there is a filter with molecular sieves (12), and between the outlet of the internal circuit and the inlet to the chamber, there is an orifice (7). The outlet of gas from the chamber (8) is conveniently connected with the outlet of gas from the system (15) through the exchanger (5) with the separating membrane (6), and at the outlet from the chamber (8), there are two pumps located in parallel, whereby the external pump (13) is located in the passage of the outlet of gas from the system (15), and the internal pump (11) is located in the passage of the inlet of gas to the chamber (8).

Dehumidifying and purifying system for air serving as carrier gas in contamination indicators

The subject of the invention is a dehumidifying and purifying system for air serving as carrier gas in contamination indicators.

When detecting H type substances, such as sulphur mustard, nitrogen mustard or lewisite, it is of utmost importance to maintain a very low concentration of steam in the air. To enable correct detection of the above substances, the relative humidity of air at 30°C should be below 1%. The presence of steam reduces sensitivity to a given substance or even makes detection impossible at high concentrations.

Measuring equipment based on conventional linear ion mobility spectrometers (IMS) comprises systems with two air circuits, the so-called internal and external ones. Both circuits are connected in an exchanger through a separating membrane.

Flow rates in the circuits are adjusted so that the concentration of a sample tested after the membrane is high and, in principle, is from 0.2 to 1 l/min.

The aim of such design of air circuits is to eliminate steam at the detector side. The filter includes molecular sieves that absorb steam from air, and the membrane in the exchanger allows entry of substances to be detected to the internal circuit and also separates the steam. The substance tested by the membrane is transferred by diffusion, so the amount of medium that can pass to the other side (to the internal circuit) is limited and depends on the physical and chemical properties of the membrane. The concentration of the substance tested at the internal circuit side depends on:

- substance concentration at the outlet side (external circuit);

- flow rate in the internal circuit;
- physical and chemical properties of the membrane.

For low flow rates, it can be assumed that the concentration of the substance tested at the internal circuit side, the upstream IMS, is virtually the same as in the external circuit at the outlet.

Increasing the flow rate in the internal circuit causes the sample tested to dilute, as the substance tested builds up on the internal circuit filter.

This leads to considerable reduction of detection threshold for both H and G type substances (organic phosphorus toxic substances).

For systems where the flow rate through a detector should be above 1.5 l/min, this solution does not satisfy the conditions for gas exchange speed, so this type of a gas system is ineffective. Such a high flow rate would cause considerable dilution of the sample, as transfer through the membrane is limited. This would significantly reduce the sensitivity of such an analyser. For flow rates above 1.5 l/min, equipment with DMS/FAIMS detectors is used. The known solution of Owlstone utilises a membrane-less system with circuit mixing. In lieu of the membrane, a tee is used, and instead of the filters, molecular sieves are provided to absorb steam without absorbing the substance tested.

This solution is unfortunately ineffective in high air humidity (above 50 % for 20°C), as the relative humidity in the internal circuit exceeds the limits at which, for example, sulphur mustard can be detected.

The dilution degree usually ranges from a few to several units.

Since the sieves absorb only steam, the concentration of the substance tested before a FAIMS detector is virtually the same as that at the inlet, and the steam concentration is considerably lower than at the inlet, but often higher than necessary to detect sulphur mustard, or at a low level. Furthermore, such a solution makes it necessary to replace the sieves.

The aim of the invention was to develop an air dehumidifying system without the above shortcomings.

A dehumidifying and purifying system for air serving as carrier gas in contamination indicators, according to the invention, comprising internal and external circuits with an exchanger with a separating membrane placed between them, with the inlet of the internal circuit connected to the inlet of gas to the measuring chamber, characterised in that the outlet of gas from the chamber is connected in parallel with the inlet of gas to the chamber and with the outlet of gas from the system, whereby, between the outlet from and inlet to the chamber, there is a filter with molecular sieves located, and between the outlet of the internal circuit and the inlet to the chamber, there is an orifice.

In a preferred embodiment of the system, the outlet of gas from the chamber is connected with the outlet of gas from the system through the exchanger with the separating membrane.

In another preferred embodiment of the system, at the outlet from the chamber, there are two pumps located in parallel, whereby the external pump is located in the passage of the outlet of gas from the system, and the internal pump is located in the passage of the inlet of gas to the chamber.

It is also preferred when the inlet of gas is connected with the inlet of the exchanger through a dust filter, an assembly of NH₃, humidity and temperature sensors and a valve.

Preferably, the outlet of the exchanger is connected with the outlet of gas from the system through the pump and the carbon filter.

The above solution forms a system for two-stage gas dehumidification, comprises two internal circuits, one with molecular sieves (only in the FAIMS/DMS chamber circuit) and the other one with a membrane.

The system with the membrane significantly reduces the humidity of air being analysed and virtually does not reduce the concentration of the substances tested, provided that the membrane material is properly selected and low air flow rates are maintained. This solution, in addition to the membrane, has a diluting system. The concentration of the substance tested in the internal dilution circuit is identical to that after

the membrane, and thanks to a low flow rate, the concentration after the membrane is virtually the same as that at the device inlet.

Therefore, with such a double internal circuit:

- The concentration of tested substance before the FAIMS/DMS detector is virtually the same as that at the inlet (only the membrane processes slightly reduce the concentrations);
- The steam concentration before the detector is very low, at several dozen ppm, which makes it possible to detect various substances at a very good level (for very low concentrations at the device inlet).

An embodiment of the invention is presented in the schematic illustration.

The inlet of gas 1 is connected through the dust filter 2, the assembly of HN3, humidity and temperature sensors 3 and the valve 4 with the exchanger inlet 5, comprising the membrane 6. The space after the membrane is connected through the orifice 7 with the inlet to the detector chamber 8, with the Ni63 ioniser 9, and the assembly of TGS02, humidity and temperature sensors 10. The chamber outlet is reversibly connected with its outlet through the internal pump 11, ensuring a flow rate of 3.51 l/min, and the filter with molecular sieves 12. The chamber outlet is connected in parallel with the exchanger 6 through the external pump 13, ensuring a flow rate within the range of 0.05 – 0.21 l/min, and the carbon filter II 14. The exchanger outlet 6 is connected with the inlet of gas from the system 15 through the pump 16, which ensures a flow rate of 1 l/min, and the carbon filter I 17. In the entire system, two blocks can be distinguished: the air intake 18 and the device for identifying the contamination 19.

Patent Claims

1. A dehumidifying and purifying system for air serving as carrier gas in contamination indicators, according to the invention, comprising internal and external circuits with an exchanger with a separating membrane placed between them, with the inlet of the internal circuit connected to the inlet of gas to the measuring chamber, **characterised in that** the outlet of gas from the chamber (8) is connected in parallel with the inlet of gas to the chamber and with the outlet of gas from the system, whereby, between the outlet from and inlet to the chamber, there is a filter with molecular sieves (12) located, and between the outlet of the internal circuit and the inlet to the chamber, there is an orifice (7).
2. System, according to claim 1, **characterised in that** the outlet of gas from the chamber (8) is connected with the outlet of gas from the system (15) through the exchanger (5) with the separating membrane (6).
3. System, according to claim 1, **characterised in that**, at the outlet from the chamber (8), there are two pumps located in parallel, whereby the external pump (13) is located in the passage of the outlet of gas from the system (15), and the internal pump (11) is located in the passage of the inlet of gas to the chamber (8).
4. System, according to claim 1, **characterised in that** the inlet of gas (1) is connected with the inlet of the exchanger (5) through the dust filter (2), the assembly of NH₃, humidity and temperature sensors (3) and a valve (4).
5. System according to claim 1, **characterised in that** the outlet of the exchanger (5) is connected with the outlet of gas from the system (15) through the pump (16) and the carbon filter (17).

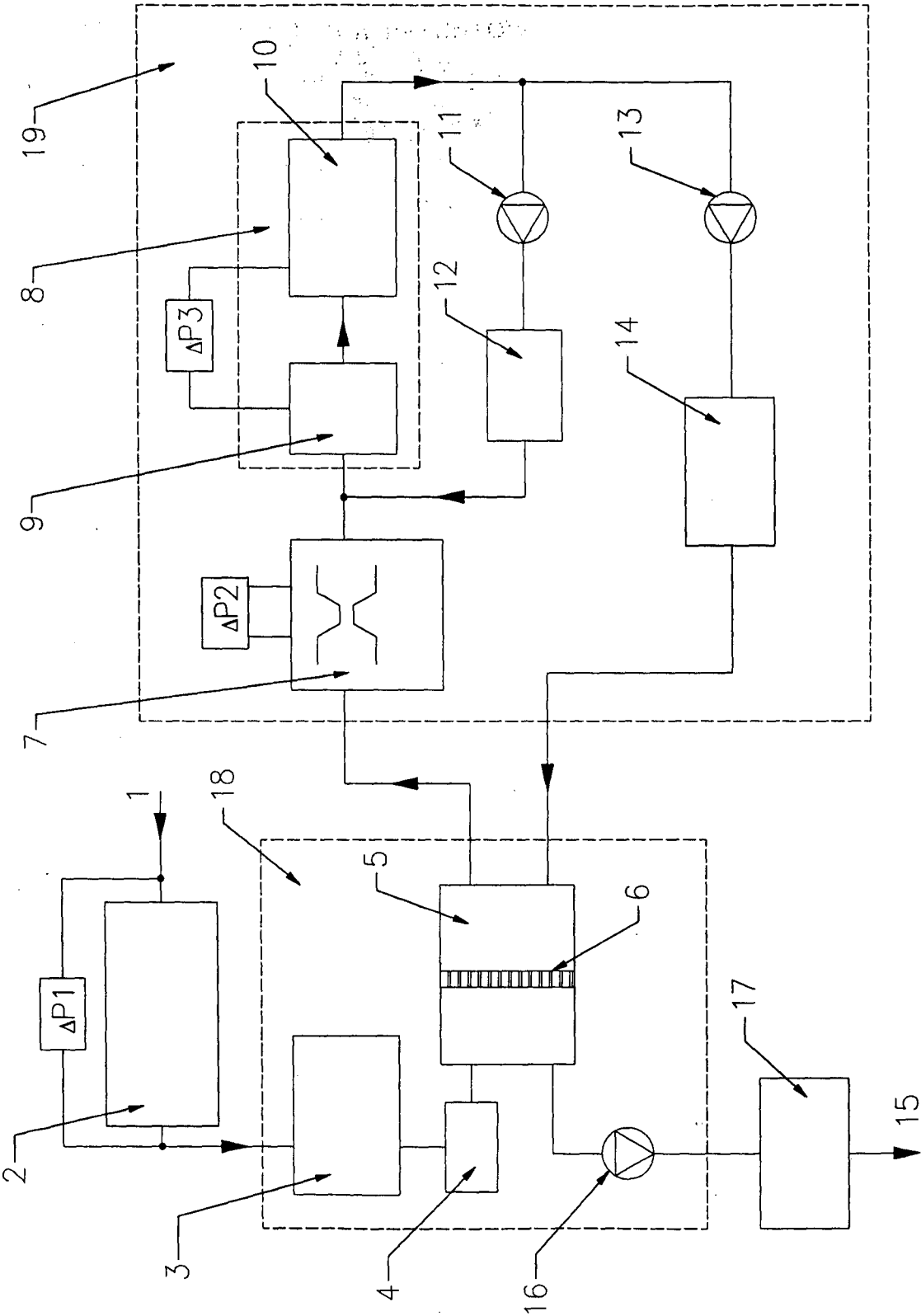


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N1/40 G01N33/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01N H01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/114812 A1 (LANDGRAF JURGEN [DE] LANDGRAF JUERGEN [DE]) 7 May 2009 (2009-05-07) the whole document	1-5
A	----- EP 0 021 518 A1 (PYE ELECTRONIC PROD LTD [GB]) 7 January 1981 (1981-01-07) abstract figure 1 page 5, line 7 - page 12, line 25	1-5
A	----- EP 0 219 602 A2 (ALLIED CORP [US]) 29 April 1987 (1987-04-29) abstract figure 1 ----- -/-	1-5



Further documents are listed in the continuation of Box C.



See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

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Name and mailing address of the ISA/

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INTERNATIONAL SEARCH REPORT

International application No
PCT/PL2014/000060

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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