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(54) **Gas analyzer with cooling apparatus**

(57) A gas analyser with an inlet port for a gas to analyse and a filter (4) with an inlet duct (5) for a gas (10) with a determined rate of humidity and an outlet duct (6) of a gas (10') with reduced values of water vapour. In particular the filter (4) provides a heat exchanger (7) adapted to cool the gas (10) and to reduce its rate of humidity by condensation. The structure of the filter com-

prises, a fastening (9) for a source of compressed air (11), a cooling device (12) of the compressed fluid (11) and a exit port (19) from the cooling device (12), for feeding the cooled fluid (17) in the heat exchanger (7) and cooling the gas (10) causing condensation of the vapour in it present. The shown embodiment adjusts the cold fluid current (17) in flow rate and in temperature responsive to the pressure as input of the compressed fluid (11).

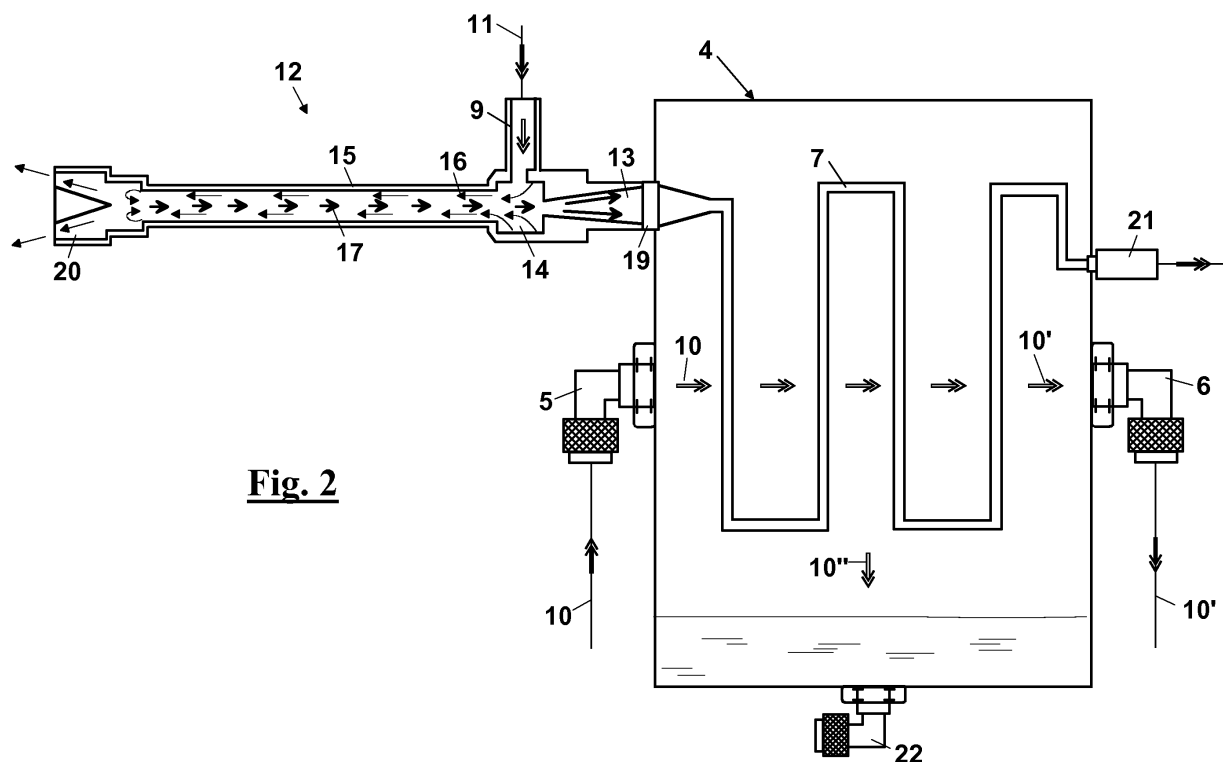


Fig. 2

Description

Field of the invention

[0001] The present invention relates to a cooling device for gas analysis of combustion gases, normally used in industrial plants.

[0002] In particular, the invention can be used in all combustion plants as well as in case of internal combustion engines.

Background of the invention

[0003] As well known, in certain industrial fields, where exhaust gases are produced that are generated by combustion, special rules are applied for controlling and monitoring the concentration of pollutants present in such gases.

[0004] Then, a dedicate equipment is necessary for exhaust gas analysis at the exit of a chimney or of an endothermic engine, in order to monitor the level of the pollutant and to warn when dangerous thresholds are exceeded.

[0005] However, in the exhaust gas coming from industrial burners or engines a high ratio of water vapour is present that influences strongly the operations of calibrating and setting the analysis equipment, as well as the operations of detecting the pollutants, such as, for example CO, CO₂ or others.

[0006] To this end, a system is used for reducing and keeping fixed the content of water vapour and of other condensable components of the gas. In particular this system provides having a gas cooling plant that allows their dehydration before the analysis. In particular the vapour and the other condensable components of the gas that can affect the measurement are retained in a refrigerator, leaving the dry gas to pass.

[0007] The known cooling devices for this purpose comprise, generally, a heat exchanger where heat is exchanged from the gas towards a cooling fluid. In particular a cooling circuit is provided comprising a compressor, a forced ventilation condenser and an evaporator. The circuit is sealed hermetically and filled of cooling fluid.

[0008] Such plants require, for their features, a lot of handwork for maintenance of the compressor and other movable parts, as well as a periodic change of the cooling fluid.

[0009] A further drawback is a difficulty in adjusting quickly the cooling circuit concerning temperature and flow rate of the cooling fluid, in order to adjust the cooling power and, then, the amount of water vapour removed. In particular, a change of cooling power is desirable when the type or the flow rate changes of the gas to analyse.

[0010] Furthermore, the known systems are stiff and not adapted to a flexible or intermittent use, since they need to achieve a steady condition for a correct operation, with subsequent high power consumption and wear owing to their cyclical use.

[0011] In addition, in industrial plants and in workshops, for safety reasons, there is often lack of electric energy socks, and the known types of mobile gas analysers with coolant circuit would require not much practical and risky electric connections.

[0012] Finally, such cooling systems are bulky, and then are heavy for a portable use, when the measuring instrument has to be moved to different sites.

Summary of the invention

[0013] It is therefore a feature of the present invention to provide a gas analyser with cooling device with a coolant fluid flow variable in flow rate and temperature.

[0014] It is also a feature of the present invention to provide a gas analyser with cooling device structurally easy and implemented in each industrial plant of analysis of the gas.

[0015] It is another feature of the present invention to provide a gas analyser with cooling device that does not require periodic maintenance operations.

[0016] It is also a feature of the present invention to provide a gas analyser with cooling device that is of minimum encumbrance.

[0017] It is a further feature of the present invention to provide a gas analyser with cooling device with a minimum energy consumption.

[0018] It is finally a feature of the present invention to provide a gas analyser with a cooling device that does not require an electric supply.

[0019] These and other objects are achieved by a gas analyser comprising:

- a gas analysis unit having an inlet port for a gas to analyse;
- a filter having an inlet duct for the gas, with a determined rate of humidity, and an outlet duct of a gas with reduced values of water vapour, said outlet duct communicating with said inlet port of the gas analysis unit,
- wherein said filter comprises a heat exchanger adapted to cool said gas as input and to reduce its rate of humidity by means of condensation, **characterised in that it comprises furthermore,**
- a fastening member for a source of compressed fluid at room temperature, in particular compressed air,
- a cooling device for said compressed fluid fed through said fastening member, wherein said cooling device provides an expansion zone for said compressed fluid that causes said fluid to cool,
- an exit port from said cooling device for feeding to said heat exchanger said cooled fluid and cooling said gas when entering the apparatus causing condensed humidity of the vapour in it present.

[0020] Advantageously, said cooling device comprises a duct having a conditioning zone where a separation of said compressed fluid is obtained respectively into a

current of warm fluid and into a cold fluid current, said cold fluid current being directed towards said exit port for feeding said heat exchanger. In particular said duct comprises, furthermore, a discharging into the environment said warm fluid current.

[0021] In particular, the fluid such as compressed air is driven into the duct in a central zone thereof, cause a vortical motion of the air at a high speed by means of tangential nozzles. This vortical motion extends along the duct reaching a discharge zone of the warm air, where a part of it is evacuated through said bleed valve. The remaining air continues to rotate in the duct and is caused to follow an opposite direction making a second vortical motion in the area of low pressure that is caused to the centre of the first vortical motion. The second vortical motion proceeds at a lower speed and the heat freed by the kinetic energy remains in the first vortical motion, such that a cold air flow exits in an opposite direction with respect to the warm air bleed valve.

[0022] Preferably, said cold fluid current is adjustable in flow rate and in temperature responsive to the compressed fluid input pressure.

[0023] Advantageously, said cold air outgoing from said exchanger is recirculated in a plant to generate compressed air.

[0024] Alternatively, said cold air outgoing from said exchanger is dispersed into the environment.

[0025] Advantageously, said filter has a container for collecting condensed humidity, and a corresponding discharge valve.

[0026] According to another aspect of the invention, a method for reducing the content of humidity of a gas that enters a gas analyser comprises the steps of:

- introducing in a filtering chamber the gas containing gas components to analyse, and cooling said gas by a heat exchanger at a temperature set between 1 and 15°C, said heat exchanger being flown through by a cold fluid coming from a cooling device;
- introducing said fluid, such as compressed air, into a duct of said cooling device;
- cooling said compressed air by an expansion of said air in said duct;
- feeding said exchanger with said cooled air.

[0027] Advantageously, said cooling step comprises the further steps of:

- forming a first vortical motion of the air that extends along a first direction along said duct;
- creating a depression zone at the centre of said first vortical motion;
- discharging into the environment a first part of the compressed air that follows said first vortical motion;
- forming in said depression zone a second vortical motion of a second part of the air, which has remained in said duct, said second vortical motion being co-axial to said first vortical motion and proceed-

ing in an opposite direction with respect to said first direction,

- reaching by said second part of the air an expansion zone;
- expanding said air in said expansion zone and forming said cooled air.

[0028] In particular, said second part of the air proceeds in said opposite direction, at a lower speed, such that the heat freed by the kinetic energy remains in said first vortical motion.

Brief description of the drawings

[0029] Further characteristic and advantages of the gas analyser with dehydration device, according to the invention, will be made clearer with the following description of an exemplary embodiment thereof, exemplifying but not limitative, with reference to the attached drawings, in which like reference characters designed the same or similar parts, throughout the figures of which:

- Fig. 1 shows diagrammatically a block diagram that identifies the steps that start from picking up the gas at the exit of a combustion plant and end with the analysis procedure;
- Fig. 2 shows diagrammatically the path of the compressed air in the cooling device and in the heat exchanger, with relative condensation of the vapours;
- Figs. 3 and 4 show a cross sectional view of a cooling filter, according to the invention;
- Fig. 5 shows a diagrammatical view of the operation of the cooling device outlining the flow of the gas and of the cooling fluid along with the electric parts.

Description of a preferred exemplary embodiment.

[0030] With reference to Fig. 1, in the block diagram the path is shown of the gas in order to analyse the polluting components in an industrial plant where combustion occurs. In particular, Fig. 1 shows a combustion plant 1 from which a sample of the gas 2 that exits from the chimney is spilled and reaches a cooling device 3 where, before reaching a gas analyser 4, a cooling of the gas occurs which, by condensing the gas humidity, reduces the ratio of water vapour present in the gas. The main reason of the dehydration is because the instruments of analysis, such as, for example, infrared sensors that allow to detect pollutants in the gas, are influenced by water molecules present in the gas, thus affecting the measurement of the pollutants.

[0031] The operation of an infrared analyser provides emission of broadband waves by a source. For each measured gas, the waves is carried out pass alternatively, through a measurement chamber at one end of which an interferential optical narrowband filter (infrared) for the gas to measure is mounted. In said cell, at a determined pressure, the gas to examine is inserted.

[0032] A suitable optical system directs the infrared waves into the measurement chamber and then to a detector that receives and amplifies alternatively the two signals, one of which is a reference signal and the other a measurement signal. The concentration of the gas is correlated monotonically to the difference between the two signals. Possible interfering agents contained in the sample, such as a high concentration of water vapour, would negatively affect the measurement.

[0033] In Fig. 2 the diagrammatical view of a conditioning unit of a gas analyser, according to the invention, comprises an gas analysing unit 4 (visible in Fig. 1) with an inlet port for a gas to analyse and a filter 3 with an inlet duct 5 for a gas 10, which has a determined rate of humidity, and an outlet duct 6 of a gas 10' with reduced values of water vapour. Furthermore, the outlet duct 6 communicates with the inlet of the gas analysing unit 4 in Fig. 1.

[0034] In particular, the filter 3 provides a heat exchanger 7 adapted to cool the gas 10 and to reduce its rate of humidity by condensation.

[0035] The structure of the filter 3 comprises, furthermore, a fastening portion 9 for a source of compressed fluid 11 at room temperature, in particular compressed air, a cooling device 12 of the compressed fluid 11 fed through the fastening portion 9 and an exit port 19 for exiting from the cooling device 12 and feeding a cooled fluid into heat exchanger 7, which cools the gas 10 causing humidity to condense.

[0036] Operatively, the cooling device 12 comprises a duct 15 with a conditioning zone 14, where a separation of the compressed fluid 11 is obtained, respectively into a warm fluid current 16 and into a cold fluid current 17. The cold fluid current 17 is directed towards exit mouth 19 for feeding the heat exchanger 4. In particular duct 15 comprises, furthermore, a bleed valve 20 for discharging into the environment the current of warm fluid 16.

[0037] In detail, the fluid 11, such as compressed air, is driven into the duct 15 in a central zone 14 thereof, causing a vortical motion of the air at a high speed by means of tangential nozzles (not shown). This vortical motion extends along the duct 15 reaching a discharge zone of the air, where the warmest part of it is evacuated through bleed valve 20. The remaining air continues to rotate in the duct 15 and is caused to follow an opposite direction proceeds according to a second vortical motion in the area of low pressure, which is created at the centre of the first vortical motion. The second vortical motion proceeds at a lower speed and the heat freed by the kinetic energy remains in the first vortical motion, such that in an opposite direction with respect to bleed valve 20 of the warmer air, a colder air flow 17 exits. In particular the cooling device 12 provides an expansion zone 13 of the compressed fluid 11 that causes the air to cool.

[0038] The cold air flow 17 crosses the heat exchanger 7 and causes the gas 10 to cool in the filter 4, from which condensed humidity 10'' is separates leaving the gas to analyse 10' to pass without a substantial content of hu-

midity. Condensed humidity 10'' is collected on the bottom of the same filter 4 and eliminated through a tap 22 whereas the cold air flow, which has adsorbed heat from the gas, comes to an outlet mouth 21, where it can be dispersed into the environment, or that can be recovered and used again if it still has a temperature lower than the environment.

[0039] The present exemplary embodiment allows to adjust the flow rate of the cold fluid current 17 and also to adjust its temperature responsive to the pressure of the compressed fluid 11;

[0040] Fig. 3 shows a cross sectional view of filter 4, according to the invention. As previously described it comprises a heat exchanger 7 that cools a gas 10 coming from a duct 5, with a measured ratio of water vapour, and causes condensed humidity to be collected in a container 25. The cold air flow 17 present in exchanger 7 is obtained by cooling device 12, visible in Fig. 4 according to an elevational side view of filter 4. One of the main advantages of such a filter is a reduced size of encumbrance, and this is advantageous in many fields, for example, portable analysers for workshops where the emissions in the engines are measured.

[0041] Fig. 5 shows a connection of the circuit of dehydration that comprises filter 4 connected directly with cooling device 12 and a thermocouple 37 that controls, by a temperature regulator 35, the cold current flow 17 that runs through heat exchanger 7 (visible in Fig. 2). The gas 10', at the exit of duct 6 of filter 4, has a reduced ratio of water vapour, and is sent to the analyser (not shown).

[0042] In particular, the compressed air flow 11 before being inserted at a determined pressure in cooling device 12 passes through a condense separator 34 and an air separator 32, in order to recover cold air 17 (visible in Fig. 2) exiting from exchanger 7. The flow rate of compressed fluid 11 is adjusted by a solenoid valve 33, connected in turn with the temperature regulator 35. This way, according to the flow rate and to the temperature of flow 11, running through duct 9 of device 12, it is possible to adjust the cooling power of the exchanger 7 (visible in Fig. 2). This solution allows a high flexibility of analysis since, according to the rate of humidity present cheap and suitably adjustable dehydration systems can be modulated. Furthermore, in the diagrammatical view of Fig. 5, a filter 31 at the outlet of a fitting 22 is present, for emptying the condensed humidity and collecting the humidity in container 25, and a pump 30 for unloading the same.

[0043] The foregoing description of a specific embodiment will so fully reveal the invention according to the conceptual point of view, so that others, by applying current knowledge, will be able to modify and/or adapt for various applications such an embodiment without further research and without parting from the invention, and it is therefore to be understood that such adaptations and modifications will have to be considered as equivalent to the specific embodiment. The means and the materials to realise the different functions described herein could have a different nature without, for this reason, departing

from the field of the invention. It is to be understood that the phraseology or terminology employed herein is for the purpose of description and not of limitation.

Claims

1. An analyser comprising:

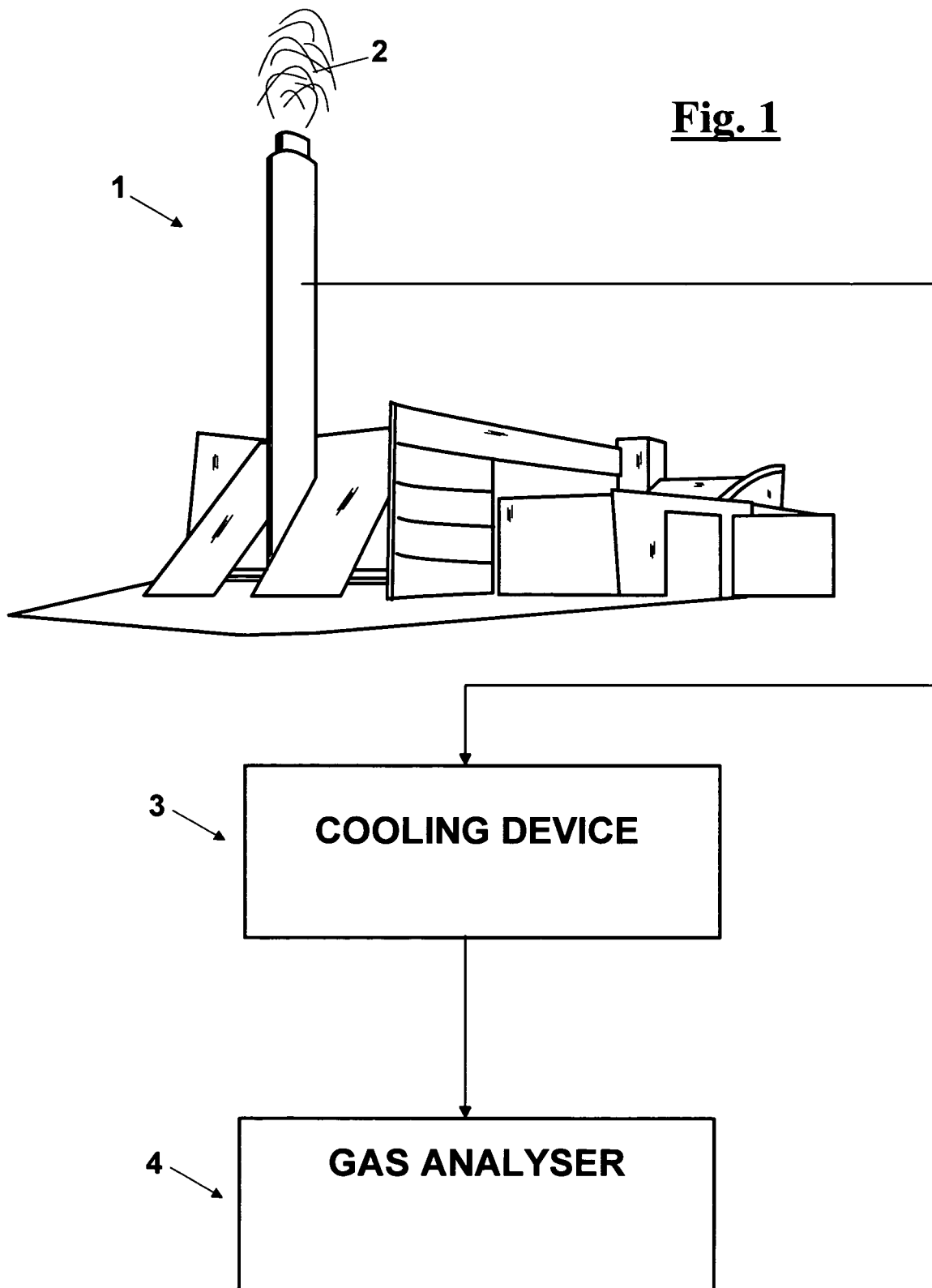
- a gas analysis unit having an inlet port for a gas to analyse;
- a filter having an inlet duct for a gas, with a determined rate of humidity, and an outlet duct of a gas with reduced values of water vapour, said outlet duct communicating with said inlet of said gas analysis unit,
- wherein said filter comprises a heat exchanger adapted to cool said gas and to reduce its rate of humidity by condensation,

characterised in that it comprises furthermore,

- a fastening member for connecting a source of compressed fluid at room temperature, in particular compressed air,
 - a cooling device for said compressed fluid fed through said fastening member, wherein said cooling device provides an expansion zone for said compressed fluid that causes said fluid to cool,
 - an exit port from said cooling device for feeding said cooled fluid to said heat exchanger and cooling said gas when entering the apparatus causing condensation of the vapour in it present.
2. An analyser, according to claim 1, wherein said cooling device comprises a duct having a conditioning zone where a separation of said compressed fluid is obtained respectively into a warm fluid current and into a cold fluid current, said cold fluid current being directed towards said exit port for feeding said heat exchanger.
3. An analyser, according to claim 2, wherein said duct comprises, furthermore, a vent for discharging into the environment said warm fluid current.
4. An analyser, according to claim 2, wherein said cold fluid current is adjustable in flow rate and in temperature responsive to the compressed fluid input pressure.
5. An analyser, according to claim 2, wherein said duct comprises nozzles arranged tangentially for causing a vortical motion to said compressed which enters said cooling device.
6. An analyser, according to claim 2, wherein said duct

comprises an expansion zone for a part of the compressed air that is not discharged from said bleed valve.

7. An analyser, according to claim 1, wherein means are provided for adjusting the flow rate of compressed fluid entering said cooling device.
8. A method for reducing the content of humidity of a gas that enters a gas analyser comprising the steps of:
- introducing in a filtering chamber the gas containing gas components to analyse, and cooling said gas by a heat exchanger at a temperature set between 1 and 15°C, said heat exchanger being flown through by a cold fluid coming from a cooling device;
 - introducing said fluid, such as compressed air, into a duct of said cooling device;
 - cooling said compressed air by an expansion of said air in said duct;
 - feeding said exchanger with said cooled air.
9. Method according to claim 8, wherein said cooling step comprises the further steps of:
- forming a first vortical motion of the air that extends along a first direction along said duct;
 - creating a depression zone at the centre of said first vortical motion;
 - discharging into the environment a first part of the compressed air that follows said first vortical motion;
 - forming in said depression zone a second vortical motion of a second part of the air, which has remained in said duct, said second vortical motion being co-axial to said first vortical motion and proceeding in an opposite direction with respect to said first direction,
 - reaching by said second part of the air an expansion zone;
 - expansion of said second part of the air making said cooled air;
10. Method according to claim 9, wherein said second part of the air proceeds in said opposite direction, at a lower speed, such that the heat freed by the kinetic energy remains in said first vortical motion.



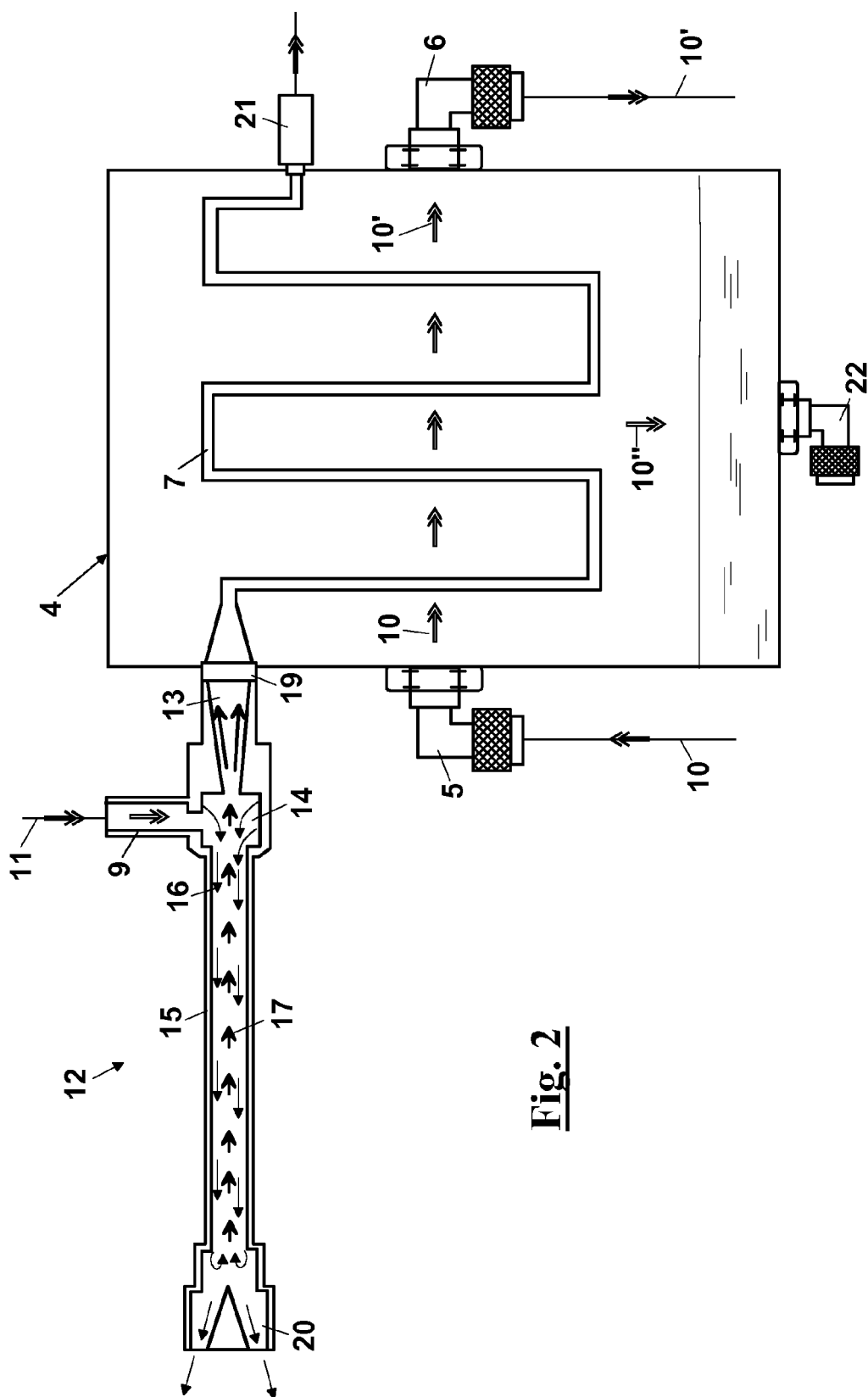


Fig. 2

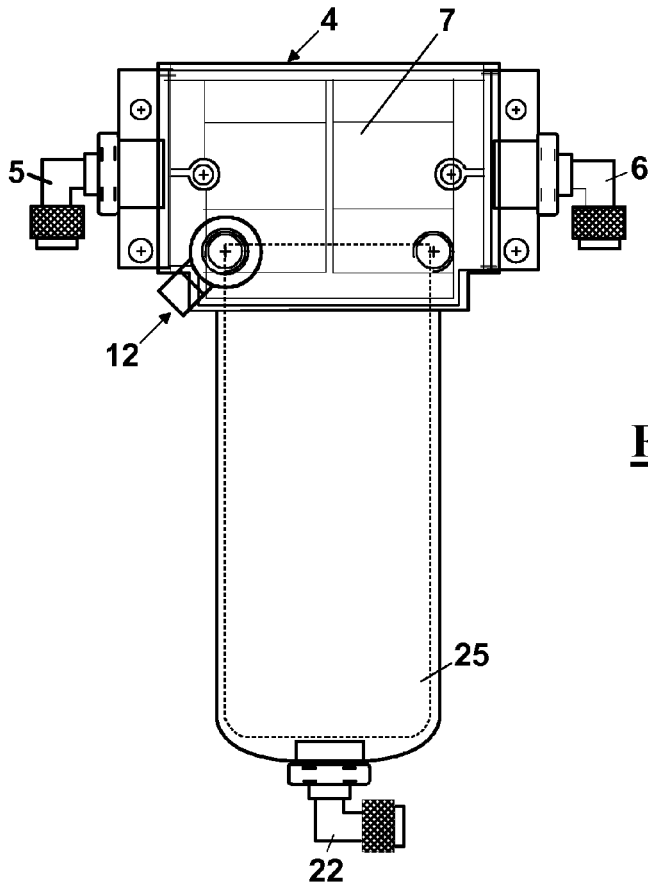


Fig. 3

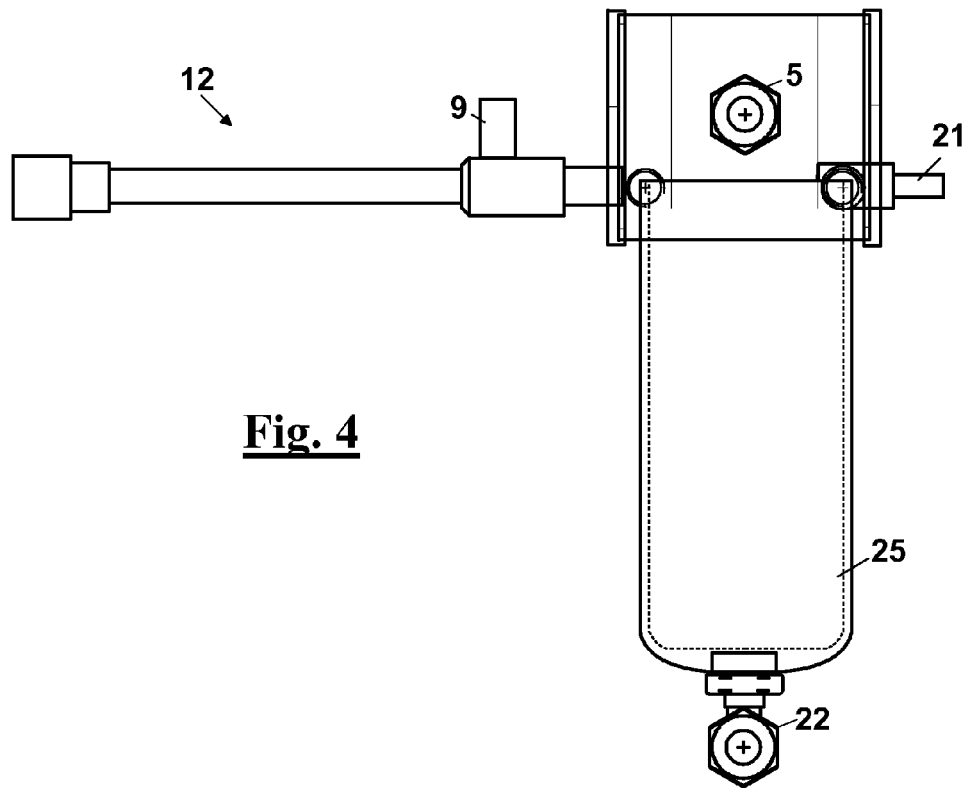


Fig. 4

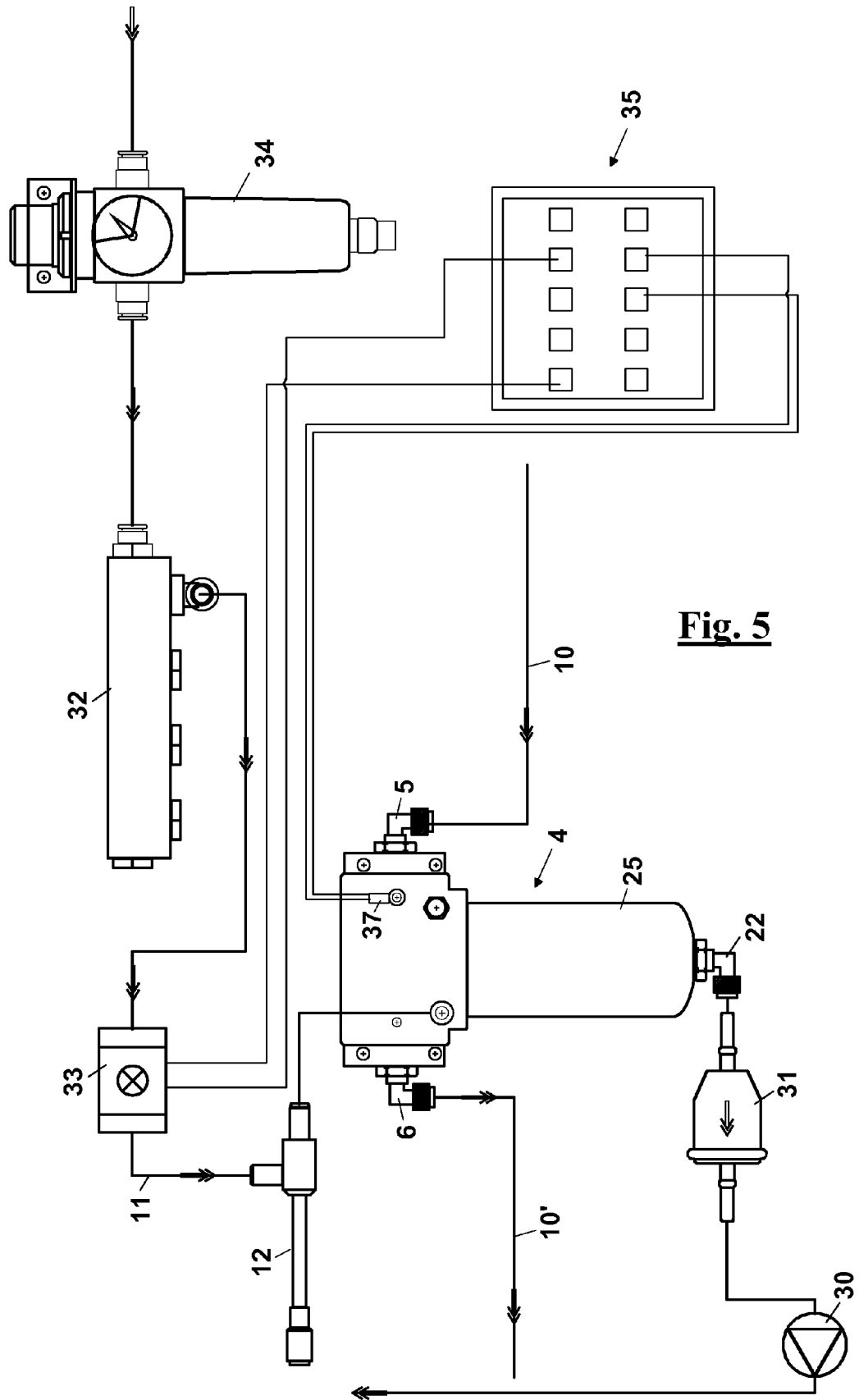


Fig. 5



EUROPEAN SEARCH REPORT

Application Number
EP 08 15 6786

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 32 32 252 A1 (AMELEN FRIEDRICH VON) 1 March 1984 (1984-03-01)	1,8	INV. G01N33/00
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A	----- EP 0 291 630 A (GROEGER & OBST MESS REGELTECH [DE]) 23 November 1988 (1988-11-23) * column 4, line 35 - column 5, line 19; figure 1 *	1-10	
A	----- DE 38 06 483 A1 (BUEHLER MESS & REGELTECH [DE]) 14 September 1989 (1989-09-14) * the whole document *	1-10	TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 6 March 2009	Examiner Stussi, Elisa
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	

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EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 08 15 6786

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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06-03-2009

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