



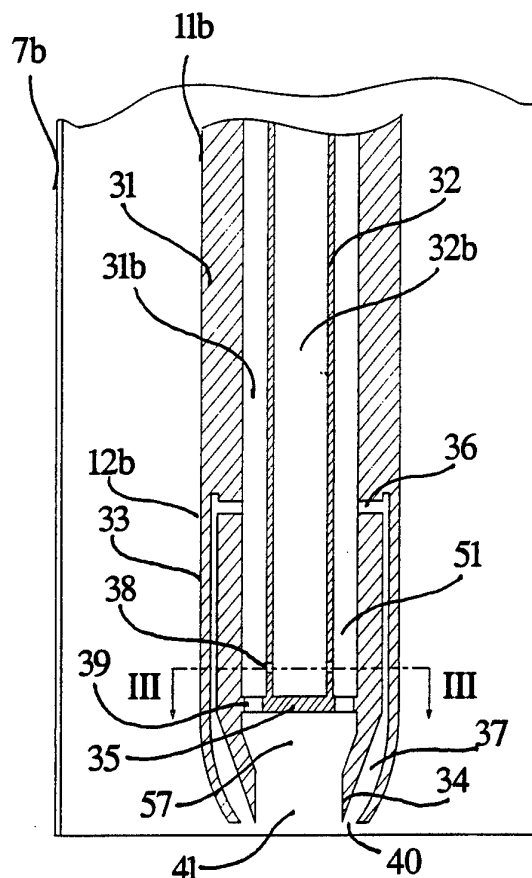
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(54) Title: APPARATUS FOR CLEANING GAS

(57) Abstract

A nozzle (12a, 12b, 12c) for atomizing a liquid, optionally containing suspended dry matter, by means of compressed gas, comprises, an inlet (32b) for liquid, an inlet (31b) for compressed gas, and an outlet (41) for gas mixed with finely divided liquid, as well as an intermediate mixing space (51). The inlet (31b) for compressed gas is adapted to give the gas a substantially rectilinear path through the mixing space (51). The inlet (32b) for the liquid is separated from the mixing space (51) by a partition (32) having a plurality of first holes (38) for introducing the liquid into the mixing space (51) in a direction substantially perpendicular to the main flow direction of the gas in the mixing space (51). The mixing space (51) is defined downstream by a wall (35) having a plurality of second holes (39). An inlet device (11a, 11b, 11c) comprising the inlet (31b) for compressed gas and the inlet (32b) for liquid consists of two concentric tubes (31, 32). The inlet (32b) for liquid consists of the inner tube (32). The inlet (31b) for compressed gas consists of the annular conduit (31b) between the concentric tubes (31, 32). The inner tube (32) is closed in the axial direction downstream of the first holes (38) provided for introducing the liquid into the mixing space (51). A convergent channel (57) connects the mixing space (51) to the outlet (41).



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APPARATUS FOR CLEANING GAS

5

TECHNICAL FIELD

The present invention relates to an apparatus for cleaning gas in order, from a flow of polluted gas, to remove
10 gaseous pollutants.

The apparatus comprises a nozzle for atomizing a liquid, optionally containing suspended dry matter, by means of compressed gas, comprising, an inlet for liquid, an inlet for compressed gas, and an outlet for gas mixed with finely
15 divided liquid, as well as an intermediate mixing space. The inlet for compressed gas is adapted to give the gas a substantially rectilinear path through the mixing space. The inlet for the liquid is separated from the mixing space by a partition having a plurality of first holes for introducing
20 the liquid into the mixing space in a direction substantially perpendicular to the main flow direction of the gas in the mixing space. The mixing space is defined downstream by a wall having a plurality of second holes.

The apparatus is especially suited for separating
25 sulphur dioxide from flue gases. In such separation, use is generally made of completely wet methods or methods where a large amount of absorbent is suspended in water and supplied in finely divided form to the flue gas, because completely dry methods do not yield satisfactory separation
30 of sulphur dioxide on account of the relatively low reactivity thereof, with inexpensive absorbents such as slaked lime or finely milled limestone.

35 BACKGROUND OF THE INVENTION

The emission of acidifying gases, such as sulphur dioxide, from e.g. coal-fired power plants has become a major

environmental problem. Several different methods have been tried in order to reduce emissions of this type.

To this end, it has been suggested both to purify the fuel and to take measures during the combustion and/or to
5 clean the flue gas produced. Certain pollutants, such as nitrogen oxides, can be dissolved in harmless substances. The formation of pollutants can also be counteracted or obviated by optimising the combustion process. Other substances, such as sulphur, can however be taken care of
10 only as a residual product and must not be emitted in any form in an uncontrolled manner. In order to remove sulphur, for example, an absorbent is generally added which contains substances forming together with sulphur stable compounds, either in the combustion chamber or in a specially designed
15 flue gas cleaning system.

Examples of prior-art methods are given in SE-8005571-8 involving the injection of absorbent into the combustion chamber, DE-36 07 357 involving wet flue gas cleaning, SE-7904382-4 involving wet-dry flue gas cleaning,
20 EP-0 177 896 involving completely dry flue gas cleaning, and SE-8505269-4 disclosing a combinatory solution.

When supplying absorbent in the combustion chamber, the major drawback is the low degree of utilisation of the absorbent. The wet flue gas scrubbers are far more
25 efficient in this respect, but involve high investment costs and maintenance problems.

Wet-dry flue gas cleaning entails lower investment costs but requires a more refined and thus more expensive absorbent than the wet flue gas scrubbers. To avoid
30 precipitation of moisture in the flue gas cleaning system, the absorbent is supplied, in the wet-dry methods, dissolved or suspended in an amount of water which is smaller than the amount required for cooling the flue gas to a temperature below the saturation temperature. The
35 amount of liquid supplied and, hence, the amount of absorbent supplied are thus limited by the heat content of the flue gas.

The completely dry methods involve the lowest investment costs for the flue gas cleaning systems, but most often require a highly refined and, thus, expensive absorbent and do not permit high-grade cleaning. The main reason for this is that solid phase reactions are slow at the temperatures normally prevailing after a coal-fired boiler.

To obtain high-grade cleaning by means of a simple flue gas cleaning system which does not include means for producing, transporting or atomizing an absorbent suspended in water, different techniques intermediate between the dry and wet-dry methods have been suggested.

SE-7908674-0, for example, suggests separate moistening of the flue gases before introduction into a bag filter, the bags of which have been coated with a dust cake of calcium hydroxide. SE-8504675-3 instead suggests moistening of the absorbent with water before it is supplied to the flue gas. The amount of water then must not be larger than as to permit maintaining the powder form of the absorbent.

None of these techniques however yields sufficiently effective flue gas cleaning according to current environmental standards. Therefore, many combinatory solutions have been suggested, according to which a completely dry absorbent as well as an absorbent suspended in water are added. Examples hereof are given in DE-32 35 341 where a dry absorbent is added upstream of an absorbent in slurry form, in SE-8500612-0 where the fresh absorbent is added in dry form while the recycled one is added in the form of a slurry, and in EP-211 458 where an absorbent in dry form and an absorbent in slurry form are added separately or together in the same contact reactor depending on operational conditions.

To supply the absorbent, different types of nozzles have been developed in compliance with the conditions in which they are to operate. Examples of nozzles for supplying and atomizing a slurry having a high dry solids content are given in EP-079 081 and EP-185 630. Examples of

nozzles for supplying a completely dry pulverulent absorbent are given in SE-8500612-0. Examples of nozzles for supplying water alone or suspensions having a low dry solids content are given in DE-26 27 880, US-4,625,916 and
5 WO-A-9112084.

DE-26 27 880 describes a nozzle substantially made of two concentric tubes or one tube with a surrounding chamber. Liquid is pumped in the inner tube, and compressed air is supplied to the outer tube or the chamber. The
10 partition is formed with a plurality of holes, through which compressed air flows into the inner tube and mixes with the liquid. The mixture leaves the tube with a step form pressure drop producing an effective disintegration of the liquid which requires little energy.

15 US-4,625,916 describes a nozzle similar to that just mentioned but which terminates in a divergent channel and, thus, probably does not give rise to any step form pressure drop at the outlet. Furthermore, the partition has holes arranged in a specific pattern in order to make the mixing
20 of air and liquid efficient.

WO-A-9112084 reveals a nozzle for atomizing a liquid to be injected into a process gas, e.g. in the separation of arsenic from a gas containing the same. The nozzle comprises a central mixing space through which the
25 atomizing gas is flowing substantially rectilinearly and into which the liquid is supplied inwards through essentially radially bored holes. Pressurized air and liquid is supplied to the nozzle in two separate parallel tubes. The nozzle comprises several pieces which are
30 threaded together and the leakage, between the inlets and to the surroundings is prevented by gaskets.

These nozzles have been found to be liable to leakage, the liquid escaping into the air duct in places where not desired, and to pressure adjustment difficulties, where
35 inequilibrium means that liquid escapes through the holes which are intended for the intake of air. If the liquid contains dry matter, such malfunctions soon result in deposits of material in the air duct system and

time-consuming cleaning operations to restore proper function.

5 OUTLINE OF THE INVENTION

TECHNICAL PROBLEM

As will have been appreciated from the above, the
10 separation of gaseous pollutants from a process gas, e.g. flue gas, is a technical problem. It is especially difficult to achieve effective separation of less reactive pollutants, such as sulphur dioxide, by methods where the absorbent, completely or to a large extent, is supplied in
15 dry form.

It is thus a major technical problem to provide a method which does not require handling substantial amounts of slurry or suspensions, which lessens the resistance to wear and impairs functional reliability, but yet permits
20 attaining substantially all the advantages of supplying the absorbent in a slurry with a high degree of utilisation of the absorbent, while supplying the main part of the absorbent in dry form.

It further is a major technical problem to provide an
25 apparatus for atomizing a suspension which is so designed that the operation is affected but to a minor extent by leakage between the channels for the compressed gas, to atomize the liquid suspension, and for the liquid suspension and by leakage from the channel for the liquid
30 suspension to the surrounding polluted gas.

OBJECTS OF THE INVENTION

35 One object of the present invention is to provide a simple apparatus for separating less reactive pollutants, such as sulphur dioxide, which can be used without major investments for new constructions, and which can be easily

applied also when reconstructing existing flue gas cleaning systems.

Another object of the invention is to provide a simple apparatus for effectively moistening dust that is recycled
5 in a gas absorption plant, and yet ensure high operational reliability and low energy consumption.

Yet another object of the invention is to provide an nozzle, which is able to atomize a liquid or a liquid suspension, without suffering from any leakage problems
10 although it can be used substantially without any rubber gaskets or the like, whereby to considerably facilitate handling, dismounting and maintenance.

15 SUMMARY OF THE INVENTION

The present invention relates to an apparatus for cleaning gas in order, from a flow of polluted gas, to remove gaseous pollutants.

20 The apparatus comprises a nozzle for atomizing a liquid, optionally containing suspended dry matter, by means of compressed gas, comprising, an inlet for liquid, an inlet for compressed gas, and an outlet for gas mixed with finely divided liquid, as well as an intermediate mixing space.

25 The inlet for compressed gas is adapted to give the gas a substantially rectilinear path through the mixing space. The inlet for the liquid is separated from the mixing space by a partition having a plurality of first holes for introducing the liquid into the mixing space in a direction
30 substantially perpendicular to the main flow direction of the gas in the mixing space. The mixing space is defined downstream by a wall having a plurality of second holes.

An inlet device comprising the inlet for compressed gas and the inlet for liquid consists of two concentric
35 tubes. The inlet for liquid consists of the inner tube. The inlet for compressed gas consists of the annular conduit between the concentric tubes.

The inner tube is closed in the axial direction downstream of the first holes provided for introducing the liquid into the mixing space.

A convergent channel connects the mixing space to the
5 outlet.

GENERAL DESCRIPTION OF THE INVENTION

10 The invention relates to an apparatus adapted for use in a method for separating gaseous pollutants from a process gas, e.g. flue gas. In this method cleaning is effected by supplying an absorbent into the gas flow in the form of dry particles and/or in the form of a liquid suspension. The
15 amount of liquid is so adjusted that the liquid is completely evaporated when contacting the gas. The thus-obtained dry dust containing unreacted absorbent and formed reaction products, is separated in a downstream dust separator and is recycled, at least partly, for re-use.

20 In this method, a carrier gas flow, such as air, is supplied with the recycled dust and optionally a fraction of fresh absorbent. The ratio of the carrier gas flow to the total flow of dry matter in the carrier gas flow may be 0.1-10 kg/standard cubic metre.

25 To this flow of heavily dust-laden carrier gas is thereafter added an atomized suspension of fresh absorbent. The suspension has a relatively low dry solids content, at the most 15%, preferably less than 10%. The purpose of this dry matter is to facilitate the transfer of moisture to the
30 recycled dust which is entrained by the carrier gas flow concerned. In fact, it has surprisingly been found that an essentially more uniform distribution of the moisture is achieved in this manner, which is of decisive importance to the separation efficiency. It has also been found
35 advantageous to use fresh absorbent in the suspension, since it is essentially more reactive than the recycled dust, this difference being of great avail, in that only fresh absorbent is supplied in suspension.

The atomization of the suspension is, according to this invention, carried out in an internal mixing nozzle with the aid of compressed gas, preferably air.

It has been found that it is possible to avoid many of
5 the problems linked with the formation of deposits when atomizing suspensions, by ensuring that the compressed gas has such a temperature and humidity that no essential evaporation of the finely divided liquid occurs during the atomization process and during the contact between the
10 compressed gas and the finely divided droplets. With such adaptation, an apparently reverse construction can operate quite excellently and, hence, it is possible to reduce leakage problems quite considerably and, consequently, manage with substantially longer intervals between
15 shutdowns for maintenance.

To attain the object of the invention, there is provided an apparatus for atomizing the suspension which comprises two concentric conduits in which liquid
20 suspension and compressed gas are brought together. As opposed to established practice in atomizing low-viscous suspensions, it is suggested that the suspension is allowed to flow into the conduit in which the gas is flowing and be conveyed out of the nozzle together by the gas. Because the
25 gas is cold and preferably moist, there is no deposit of dry matter in the gas conduit, since no drying takes place. Any matter, which all the same may adhere to the walls, is still conveyed away by the flowing gas. Another advantage is that any leakage that may occur between the conduits is
30 of no consequence. If joints between parts of the nozzle and the supply ducts should leak, it is possible, by the positioning of the conduit for the supply of the suspension inside the air conduit, to prevent the suspension from spurting out as a jet into the carrier gas laden with dry
35 recycled dust, or into the polluted gas, where it dries and deposits on ducts or other construction details. It will now only emerge into the conduit for the compressed gas and be conveyed away thereby.

The mixing space, being a direct extension of the gas conduit, terminates in a washer without any special sealing against the nozzle walls, whereby to obtain a construction which is easy to manufacture and dismount.

5

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with
10 reference to the accompanying drawings, in which

Fig. 1 schematically shows an apparatus for carrying out a method of gas cleaning using the nozzle according to the invention;

15

Fig. 2 is a vertical section of a nozzle according to the present invention; and

Fig. 3 is a cross-section of the nozzle in Fig. 2.

20

DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 schematically shows an apparatus, for carrying out a
25 gas cleaning method, using the nozzles according to the invention, having a duct 1 for a flow of polluted gas, from an incineration plant (not shown). The gas is conducted through the duct 1 into a reactor 8. A carrier gas flow is drawn in through a duct 2, and is pumped by a fan 3 through
30 a duct 4 where it is supplied, via the inlet means 5, with dust which is recycled from a dust separator (not shown) located downstream of the reactor 8.

The dust-laden carrier gas flow is conducted through the duct 4 to a distributor 6 where it is divided into a
35 plurality of partial flows which, via a plurality of large tubes 7a, 7b, 7c of a diameter of 100 mm, are conducted into the reactor 8 and mixed with the flue gas. The dust-laden mixture of flue gas and carrier gas is passed

from the reactor 8 on to the dust separator (not shown) in which the dust is separated, and the main part of it is recycled to the flue gas via the inlet means 5 in the duct 4.

5 Within the large tubes 7a, 7b, 7c, there are provided double-shelled tubes 11a, 11b, 11c having an outer diameter of 40 mm (drawn in plain lines for greater clarity), to which are supplied a diluted lime suspension, via a conduit 9, and compressed air, via a conduit 10. The lime
10 suspension is atomized in nozzles 12a, 12b, 12c arranged in the lower ends of the double-shelled tubes 11a etc., and is injected into the carrier gas partial flows mixed with recycled dust. As described below, the nozzles 12a etc. are arranged in the vicinity of the outlets 13a etc. of the
15 large tubes 7a etc., preferably immediately upstream of the respective outlets.

Fig. 2 is a vertical section illustrating in more detail
20 the outlet 13b of the large tube 7b and the associated nozzle 12b. The double-shelled tube 11b consists of an outer thick wall 31 and a concentric inner, thinner wall 32 enclosing a cylindrical conduit 32b having a diameter of 10 mm. Between these walls is defined an annular conduit 31b
25 having an inner diameter of 12 mm and an outer diameter of 30 mm. The conduits 31b and 32b both terminate at a transverse wall in the form of a nozzle washer 35 having eight circular holes 39 of a diameter of 6 mm located in the annular conduit 31b, but completely closed opposite the
30 duct 32b. Through the thin wall 32, between the conduit 32b and the annular conduit 31b, extend radial holes 38 of a diameter of 3 mm which are located just in front of the holes 39 in the nozzle washer 35.

The outer wall 31 changes at the nozzle 12b into a
35 thinner shell 33 surrounding an annular cavity 37, in turn surrounding the outer wall 34 of the nozzle 12b. Via radial holes 36, the annular conduit 31b communicates with the annular cavity 37. The nozzle 12b terminates in a

convergent channel 57 and a circular opening 41 of a diameter of 11 mm downstream of the circular holes 39 in the nozzle washer 35. The annular cavity 37 opens in an annular opening 40 having an outer diameter of 20 mm,
5 between the outer wall 34 of the nozzle and the thinner shell 33.

To facilitate manufacture and maintenance, the nozzle 12b consists of several easily detachable parts which are screwed together or inserted in each other. Thus, for
10 example, the nozzle washer 35 with a portion of the tube 32 is loosely inserted in the outer wall 34 of the nozzle which in turn is threadedly connected to the thick wall 31. For reasons of clarity, this is not shown in the Figure.

15 Fig. 3 is a section of the nozzle 12b taken along the line III-III in Fig. 2. The reference numerals agree with those in Fig. 2.

The nozzle operates as follows. Reference is being
20 made to Fig. 1 and Fig. 2.

Cold and optionally moistened compressed air is pumped through the annular conduit 31b from means (not shown) to the nozzle 12b and out through the circular holes 39 in the nozzle washer 35 and thence out through the circular
25 opening 41 to be mixed with the dust-laden carrier gas which is blown through the tube 7b by the fan 3.

Through the cylindrical conduit 32b is pumped, by means (not shown), a lime suspension having a dry solids content of about 5-10%. This suspension is pressed out
30 through the radial holes 38 in the wall 32 into the surrounding annular mixing space 51 in the extension of the conduit 31b, where it is atomized by the flowing compressed air and conveyed through the circular holes 39 in the nozzle washer 35 so as to be further atomized, and on
35 through the convergent channel 57 and the opening 41 of the nozzle 12b out into the surrounding carrier gas mixed with recycled dust.

The annular cavity 37 is supplied with compressed air via the radial holes 36 in the thick wall 31. This compressed air flows from this annular cavity out through the annular opening 40 between the wall 34 of the nozzle and the surrounding thin shell surface 33. This emerging air is not mixed with lime-containing water droplets and acts as a screen serving to prevent wet lime, because of the generation of eddies, from being deposited on the nozzle surface with ensuing soiling problems and impaired function, necessitating short cleaning intervals.

CLAIMS

1. A nozzle (12a, 12b, 12c) for atomizing a liquid, optionally containing suspended dry matter, by means of
5 compressed gas, comprising an inlet (32b) for liquid, an inlet (31b) for compressed gas, and an outlet (41) for gas mixed with finely divided liquid, as well as an intermediate mixing space (51), in which
the inlet (31b) for compressed gas is adapted to give
10 the gas a substantially rectilinear path through the mixing space (51),
the inlet (32b) for the liquid is separated from the mixing space (51) by a partition (32) having a plurality of first holes (38) for introducing the liquid into the mixing
15 space (51) in a direction substantially perpendicular to the main flow direction of the gas in the mixing space (51), and
the mixing space (51) is defined downstream by a wall (35) having a plurality of second holes (39),
20 c h a r a c t e r i s e d i n
that an inlet device (11a, 11b, 11c) comprising the inlet (31b) for compressed gas and the inlet (32b) for liquid
25 consists of two concentric tubes (31, 32),
that the inlet (32b) for liquid consists of the inner tube (32), and the inlet (31b) for compressed gas consists of the annular conduit (31b) between the concentric tubes (31, 32),
30 that the inner tube (32) is closed in the axial direction downstream of the first holes (38) provided for introducing the liquid into the mixing space (51), and
that a convergent channel (57) connects the mixing space (51) to the outlet (41).

2. A nozzle as claimed in claim 1,
c h a r a c t e r i s e d in that the mixing space (51)
essentially consists of an extension of the annular conduit
(31b) between the tubes (31, 32).

5

3. A nozzle as claimed in claim 1 or 2,
c h a r a c t e r i s e d in that the first holes (38) are
arranged in a plane perpendicular to the inner tube (32),
extend substantially radially and are located in the
10 immediate vicinity of the wall (35) which defines the
mixing space (51) downstream.

4. A nozzle as claimed in claim 3,
c h a r a c t e r i s e d in that the first holes (38) are
15 substantially uniformly distributed round the circumference
of the inner tube (32).

5. A nozzle as claimed in claim 3 or 4,
c h a r a c t e r i s e d in that the second holes (39) in
20 the wall (35) defining the mixing space (51) downstream are
arranged equiangularly with respect to the first holes (38)
introducing the liquid into the mixing space (51).

6. A nozzle as claimed in claim 1, 2, 3, 4 or 5,
25 c h a r a c t e r i s e d in that the diameter of the
inner tube (32) is 5-20 mm, the diameter of the outer tube
(31) is 20-60 mm, the diameter of the outlet (41) 5-20 mm,
the diameter of the first holes (38) are 2-6 mm, and the
diameter of the second holes (39) are 5-10 mm.

30

7. A nozzle as claimed in any of claims 1 to 6,
c h a r a c t e r i s e d in that a surrounding shell (33)
defining an annular space (37) round the outer wall (34) of
5 the nozzle (12b) is arranged to communicate with the inlet
(31b) for compressed gas via third holes (36), and to
produce, via an annular gap (40) at the outlet (41) of the
nozzle, a gas curtain round the mixture of gas and atomized
liquid leaving through the outlet of the nozzle.

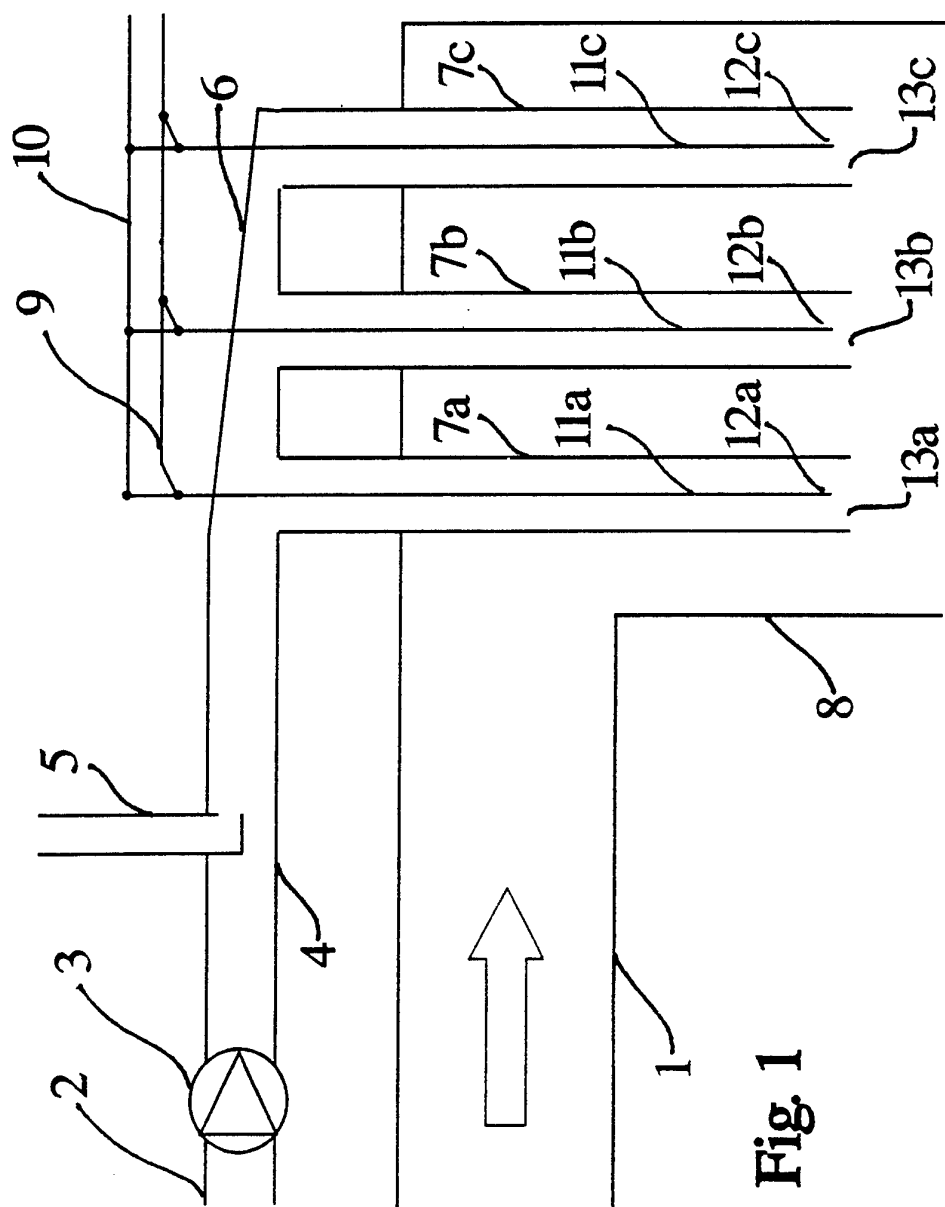


Fig. 1

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 93/00810

A. CLASSIFICATION OF SUBJECT MATTER

IPC5: B01D 53/34, B05B 7/04

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)

IPC5: B01D, B05B

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

SE,DK,FI,NO classes as above

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	SE, B, 465502 (SVEN JOHANSSON), 23 Sept 1991 (23.09.91), page 9, line 20 - line 33, figure 5 -----	1-7

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

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Date of the actual completion of the international search

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INTERNATIONAL SEARCH REPORT

Information on patent family members

27/11/93

International application No.

PCT/SE 93/00810

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
SE-B-	465502	23/09/91	AU-A-	7301391	03/09/91
			SE-A-	9000492	13/08/91
			WO-A-	9112084	22/08/91
