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(54) **Title:** APPARATUS FOR DETECTING AND LOCATING FAILED FILTER BAGS IN A BAGHOUSE USING CAPACITANCE

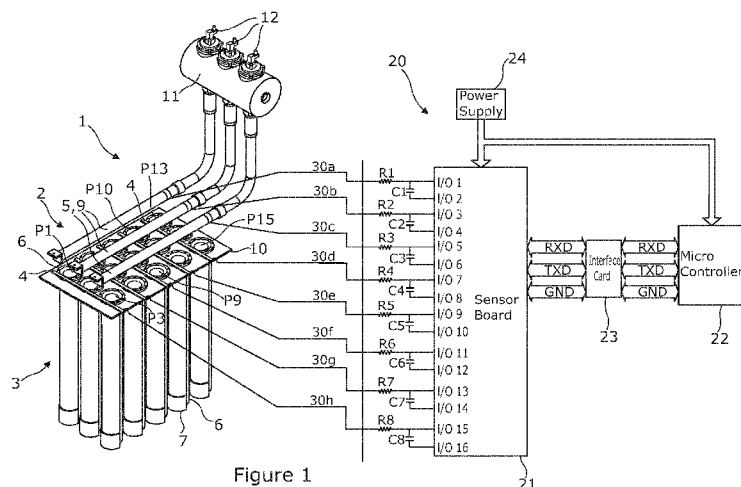


Figure 1

(57) **Abstract:** An apparatus (1) for detecting and locating failed filter bags in a baghouse comprising: a grid of conductive material (2) for sensing a change in capacitance, the grid of conductive material disposed above a filter cage assembly (3); and a processing device (20) for determining the location of the change in capacitance, the processing device (20) coupled to the grid of conductive material (2); wherein the grid of conductive material (2) is comprised of a first conductive component (4) disposed in a lateral x-direction and a second conductive component (5) disposed in a longitudinal y-direction.

APPARATUS FOR DETECTING AND LOCATING FAILED FILTER BAGS IN A BAGHOUSE USING CAPACITANCE

FIELD OF THE INVENTION

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The present invention relates to industrial baghouses and more particularly to an apparatus for detecting and locating leaks in the individual filter bags within the baghouse.

BACKGROUND OF THE INVENTION

Emphasis on environmental quality has resulted in more strenuous regulatory controls on industrial emissions. As a result, fabric filtration has proven to be highly efficient in controlling air pollution. In the cement industry, fabric filtration is carried out in e.g. dust collection apparatuses which are commonly known as baghouses. Baghouses typically include a housing (e.g. made of sheet metal) divided into two or more chambers, referred to as plenums, by one or more sheets. Disposed within openings communicating with the plenums are filters in the form of filter bags constructed of a suitable fabric. For structural rigidity filter bags are typically disposed around filter cages. A particle laden gas stream, induced by the action of a fan (from e.g. a manifold air tank), flows into one chamber (dirty air plenum) where dust accumulates on the filter bags as the gas passes through the fabric into the other chamber (clean air plenum) and out the exhaust.

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With continued use the filter bags eventually become worn and develop leaks which hamper their effectiveness in filtering particulate matter from the gas. It is normal practice to regularly replace the entire array of filter bags at scheduled intervals since the majority of the bags reach the end of their useful life at approximately the same time. In addition, there are invariably some filter bags which become worn prematurely and leak excessively prior to their regularly scheduled replacement. Such defective filter bags must be quickly located and

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replaced or repaired in order to maintain the baghouse at peak operating efficiency and in compliance with emissions standards.

5 However, since the baghouse often contains hundreds or even thousands of filter bags, it is extremely difficult and time consuming to identify the individual filter bags which are defective. In the past, it has been the typical practice for maintenance personnel to physically enter the baghouse compartments and visually inspect the filter bags to determine which filter bags are defective and then repair or replace them. The time and effort involved in this labor intensive
10 procedure adds significantly to the overall cost of operating the baghouse and to its off-line time, as well as increasing the risk of physical injury to the maintenance crew due to the hostile conditions encountered in the baghouse and the lengthy time periods during which the workers must be physically present therein. Furthermore, visual examination of the filter bags often results in some
15 of the defective filter bags being overlooked due to human error.

More advanced techniques include using optical fibers disposed on each of the filter bags in order to identify which filter bags are defective. However, this process is inefficient, impractical and problematic. For example, constant
20 cleaning of the optical sensors is needed during operation to keep the optical sensors free of dust and prevent them from malfunctioning.

It is thus apparent that there is a need to reduce the time, labor, and safety hazards involved in identifying defective filter bags in a baghouse and a need to
25 provide an apparatus for doing so which will function in the presence of dust and will not require constant cleaning.

OBJECT OF THE INVENTION

30 It is an object of the invention to overcome or at least alleviate one or more of the above problems and/or provide the consumer with a useful or commercial choice. More specifically, it is an object of the invention to provide, in a baghouse, a

reliable and practical apparatus for quickly and precisely identifying each individual filter bag which leaks to an unacceptable extent.

SUMMARY OF THE INVENTION

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An apparatus for detecting and locating failed filter bags in a baghouse is provided. The apparatus may comprise: a grid of conductive material for sensing a change in capacitance, the grid of conductive material disposed above a filter cage assembly; and a processing device for determining the location of the
10 change in capacitance, the processing device coupled to the grid of conductive material. The grid of conductive material may be comprised of a first conductive component disposed in a lateral x-direction and a second conductive component disposed in a longitudinal y-direction.

15 In an exemplary embodiment of the apparatus, the filter cage assembly may be comprised of a filter cage and a corresponding filter bag arranged around the periphery of the filter cage.

In an exemplary embodiment of the apparatus, the filter cage assembly may
20 comprise a venturi disposed within the filter cage.

In an exemplary embodiment of the apparatus, the first conductive component may be comprised of bars or strips. In an exemplary embodiment, the bars or the strips may be comprised of copper. In an exemplary embodiment, the bar or
25 the strips may be attached to the filter cage assembly.

In an exemplary embodiment of the apparatus, the second conductive component may be a purge tube. In an exemplary embodiment, the second conductive component may be located on the purge tube. In an exemplary
30 embodiment, the second conductive component may be located above the first conductive component. In an exemplary embodiment, there may be a gap between the first conductive component and the second conductive component. In an exemplary embodiment, the gap may be approximately 150 mm.

In an exemplary embodiment of the apparatus, the processing device may be comprised of a sensor board and a microcontroller.

5 In an exemplary embodiment of the apparatus, the first conductive component and the second conductive component may form grid points above the filter cage assembly wherein each of the grid points correspond to a single filter cage or filter bag.

10 In an exemplary embodiment of the apparatus, the sensor board may be coupled to the grid of conductive material via channels, wherein the channels may correspond to rows and columns of filter bags. A first set of channels may correspond to columns of filter bags and a second set of channels may correspond to rows of filter bags.

15 Other details, objects, and advantages of the invention will become apparent as the following description of certain present exemplary embodiments thereof and certain present exemplary methods of practicing the same proceeds.

BRIEF DESCRIPTION OF THE FIGURES

20 Embodiments of the invention, by way of example only, will be described with reference to the accompanying drawings in which:

25 Figure 1 shows an overview of an exemplary embodiment of the apparatus according to the invention.

Figure 2 shows an overview of an exemplary embodiment of the filter cage according to the invention.

30 DETAILED DESCRIPTION OF THE INVENTION

Figure 1 depicts an exemplary embodiment of an apparatus 1 for detecting and locating failed filter bags in a baghouse. As shown, the apparatus may contain a

filter cage assembly 3. In an exemplary embodiment, the filter cage assembly 3 contains filter bags 7. In order to strengthen the filter bag 7 the filter cage assembly 3 may also contain a filter cage 6 (as shown in Figure 2). In some embodiments, the filter cage 6 can be a ground insulated wire welded structure and the filter bag 7 can be arranged around the periphery of the filter cage 6. In some embodiments (as also shown in Figure 2), a venturi 8 may be disposed within the filter cage 6 (e.g. on the top vertical side of the filter cage 6 or immersed within the interior of the filter cage 6) to assist with uniform distribution of compressed air inside of the filter cage 6. A tube sheet 10 may be vertically disposed in a horizontal plane above the filter cages 6 and filter bags 7 in order to mechanically support, arrange or connect the filter cages 6 and filter bags 7. The filter cages 6 with corresponding filter bags 7 (and the first/second conductive components 4, 5) may be electrically insulated from the tube sheet 10. Such electrical insulation is advantageous when neither the first/second conductive components 4, 5 nor the filter cage assembly 3 are grounded. In an exemplary embodiment, in order to accurately sense a change in capacitance, neither the first/second conductive components 4, 5 nor the filter cage assembly 3 are grounded.

As further shown in Figure 1, in an exemplary embodiment the filter cages 6 with corresponding filter bags 7 may be arranged in a 4 (row) x 3 (column) grid. It may be appreciated that in operation there will be significantly more columns and/or rows. Rows of the filter cages 6 with corresponding filter bags 7 may be connected using a first conductive component 4. The first conductive component 4 can be in the form of bars or strips. The first conductive component 4 may be disposed over the tube sheet 10 and attach e.g. onto the side(s) of the filter cages 6 / filter bags 7. In some embodiments the bars or the strips are comprised of copper. The first conductive component 4 may be arranged so that it is substantially perpendicular to the second conductive component 5. In some embodiments, the second conductive component 5 can be placed on e.g. purge tubes 9. In other embodiments, the second conductive components are the purge tubes 9. In some embodiments each of the purge tubes 9 are arranged over a column of filter cages 6 / filter bags 7. In some embodiments, the purge tubes 9

are comprised of steel. For example, the purge tubes 9 may be mild steel tubes with air holes along their length, the holes being aligned to the center of the respective filter cages 6. Together, the first conductive component 4 which is disposed in the lateral x-direction and a second conductive component 5 which is disposed in a longitudinal y-direction form a grid of conductive material 2 arranged in a plane above the filter cage assembly 3. In some embodiments there is a vertical gap between the first conductive component 4 and the second conductive component 5. In some embodiments, the vertical gap is approximately 150 mm. Such a vertical gap assists in e.g. the expansion of compressed air inside the filter cages 6/ venturi 8.

In operation, dust can be passed through the filter bag 6 whereby the dust gets deposited on the surface of the filter bag 6 and clean air comes out the other side of the filter bag 6. The deposited dust on the outer surface of the filter bag may be cleaned by introducing compressed air into the filter bag 6 via e.g. a manifold air tank 11. The compressed air from the manifold air tank 11 may be given a short pulse using e.g. solenoid purge valves 12. The air from the purge valves 12 passes through purge tubes 9 (or other second conductive components 5) which may be connected to the manifold air tank 11. The purge tubes 9 may have small air holes along the length of the purge tubes 9 for air to release. The holes are in line with the holes in the top of the filter bags 6.

The grid of conductive material 2 is capable of sensing a change in capacitance due to failed filter bags 7. The first conductive component 4 and the second conductive component 5 form grid points (p) above the filter cage assembly 3. Each of the grid points (p) correspond to a single filter cage 6 / filter bag 7. For example, as shown in Figure 1, grid point p1 corresponds to the filter bag 7 in row 1, column 1; grid point p2 corresponds to the filter bag 7 in row 1 column 2; grid point p3 corresponds to the filter bag 7 in row 1, column 3; grid point p4 corresponds to the filter bag in row 2 column 1; grid point p5 corresponds to the filter bag 7 in row 2, column 2; grid point p6 corresponds to the filter bag in row 2 column 3; grid point p7 corresponds to the filter bag 7 in row 3, column 1; grid point p8 corresponds to the filter bag in row 3 column 2; grid point p9

corresponds to the filter bag 7 in row 3, column 3; grid point p10 corresponds to the filter bag in row 4 column 1; grid point p11 corresponds to the filter bag 7 in row 4, column 2; grid point p12 corresponds to the filter bag in row 4, column 3; grid point p13 corresponds to the filter bag 7 in row 5, column 1; grid point p14
5 corresponds to the filter bag in row 5, column 2; grid point p15 corresponds to the filter bag 7 in row 5, column 3.

Figure 1 also depicts a processing device 20. In some embodiments, the processing device 20 may be coupled to the grid of conductive material 2. The
10 processing device 20 can determine the location of the change in capacitance which was sensed by the grid of conductive material 2. In an exemplary embodiment, the processing device 20 is comprised of a sensor board 21 and a microcontroller 22. The processing device 20 may be connected to the grid of conductive material 2 by lead channels 30. In particular the lead channels 30
15 may be connected directly from the grid of conductive material 2 to the sensor board 21. In one exemplary embodiment the first conductive component 4 may be connected to the sensor board 21 via channels (30d-30h) and the second conductive component 5 is connected to the sensor board via other channels (30a-30c). The microcontroller 22 can be connected to the sensor board 21 via
20 an interface card 23. For example, the interface card 23 can be an RS232 interface card. In some embodiments a power supply 24 supplies power to the microcontroller 22 and the sensor board 21.

The microcontroller 22 is able to calculate the capacitance measured from the
25 sensor board 21. For example, during normal operation of the filter bags 7, the gap between the first conductive component 4 and the second conductive component 5 has only clean air and therefore a certain constant capacitance value which is sensed by the grid of conductive material 2 and measured by the processing device 20. During the case of a failed filter bag 7, the dust from the
30 corresponding failed filter bag 7 comes out into the clean air side and passes through the gap between the first conductive component 4 and the second conductive component 5 which results in a capacitive value change sensed by

the grid of conductive material 2. The processing device 20 is then able to measure and determine the precise location of the failed filter bag 7.

By way of further example, if the filter bag 7 located in row 3 and column 2 (p8) in Figure 1 bursts, a change in capacitance will be sensed by the grid of conductive material 2 in the gap above that filter bag 7. The processing device 20 will then be able to measure and determine the precise location of the failed filter bag 7. For example, the capacitance value change will be sensed by channels 30b and 30f which corresponds to filter bag p8.

It is to be understood that the form of this invention as shown is merely a preferred embodiment. Various changes may be made in the function and arrangement of parts; equivalent means may be substituted for those illustrated and described; and certain features may be used independently from others without departing from the spirit and scope of the invention as defined in the following claims.

LIST OF COMPONENTS

	1	apparatus
	2	grid of conductive material
5	3	filter cage assembly
	4	first conductive component (x-component)
	5	second conductive component (y-component)
	6	filter cage
	7	filter bag
10	8	venturi
	9	purge tube
	10	tube sheet
	11	manifold air tank
	12	purge valve
15	20	measuring device
	21	sensor board
	22	microcontroller
	23	interface card
	24	power supply
20	30, 30a-30h	channels
	p, p1-p15	grid points

CLAIMS

1. An apparatus (1) for detecting and locating failed filter bags in a baghouse comprising:
 - 5 a grid of conductive material (2) for sensing a change in capacitance, the grid of conductive material (2) disposed above a filter cage assembly (3); and
 - a processing device (20) for determining the location of the change in capacitance, the processing device (20) coupled to the grid of conductive material (2);
- 10 wherein the grid of conductive material (2) is comprised of a first conductive component (4) disposed in a lateral x-direction and a second conductive component (5) disposed in a longitudinal y-direction.
2. The apparatus (1) of claim 1 wherein the filter cage assembly (3) is
15 comprised of a filter cage (6) and a corresponding filter bag (7) arranged around the periphery of the filter cage (6).
3. The apparatus of claim 1 wherein the first conductive component (4) is comprised of bars or strips.
- 20 4. The apparatus of claim 3 wherein the bars or the strips are comprised of copper.
5. The apparatus of claim 3 wherein the bars or the strips are attached to the
25 filter cage assembly (3).
6. The apparatus of claim 1 wherein the second conductive component (5) is a purge tube (9).
- 30 7. The apparatus of claim 1 wherein the second conductive component (5) is located above the first conductive component (4).

8. The apparatus of claim 1 wherein the processing device (20) is comprised of a sensor board (60) and a microcontroller (50).

5 9. The apparatus of claim 2, wherein the first conductive component (4) and the second conductive component (5) form grid points (p) above the filter cage assembly (3) and wherein each of the grid points (p) correspond to a single filter cage (6) or filter bag (7).

10 10. The apparatus of claim 8 wherein the sensor board (60) is coupled to the grid of conductive material (2) via channels (30a-30h) and wherein a first set of channels (30a-30c) corresponds to columns of filter bags (7) and a second set of channels (30d-30h) correspond to rows of filter bags (7).

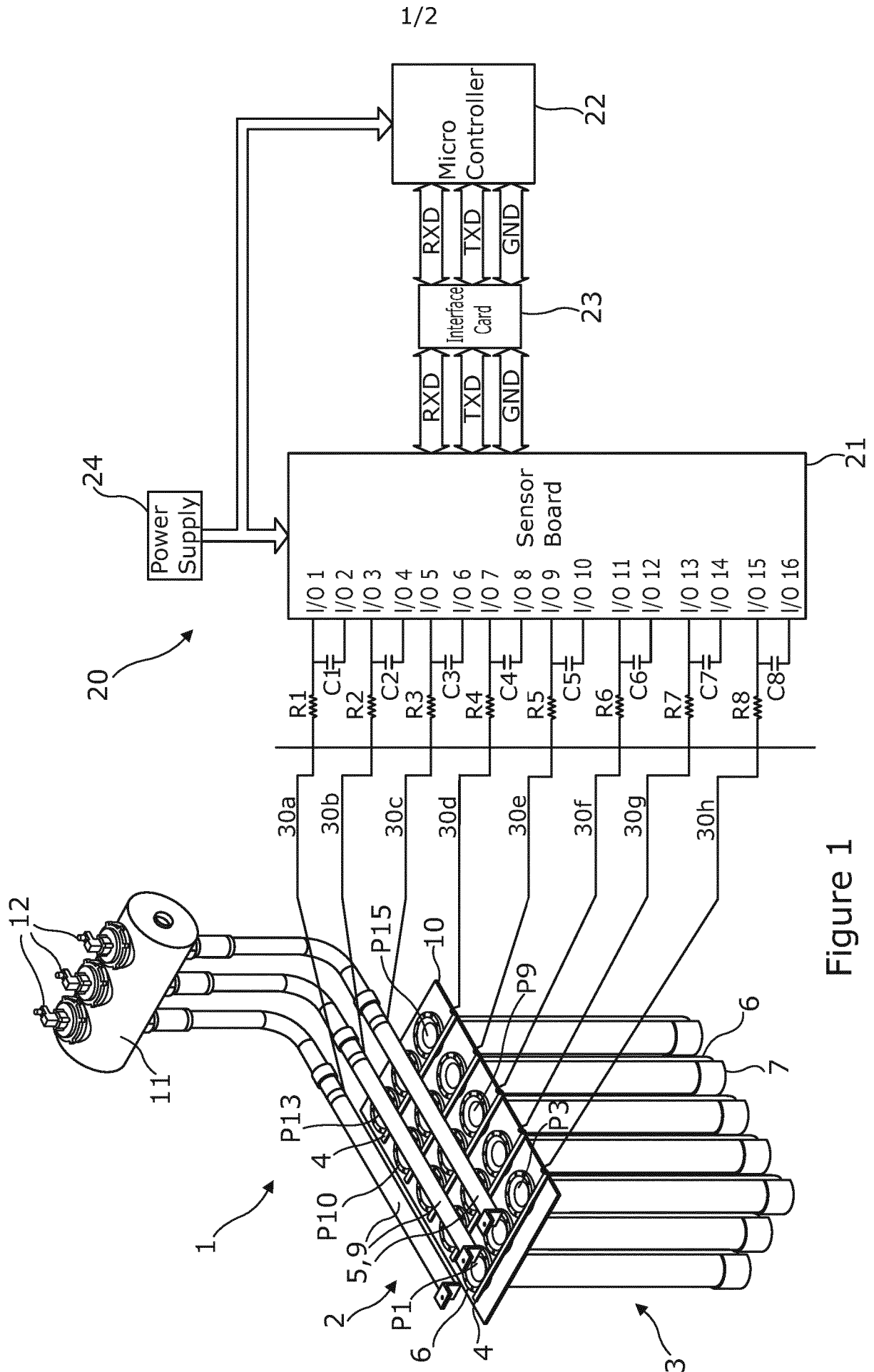


Figure 1

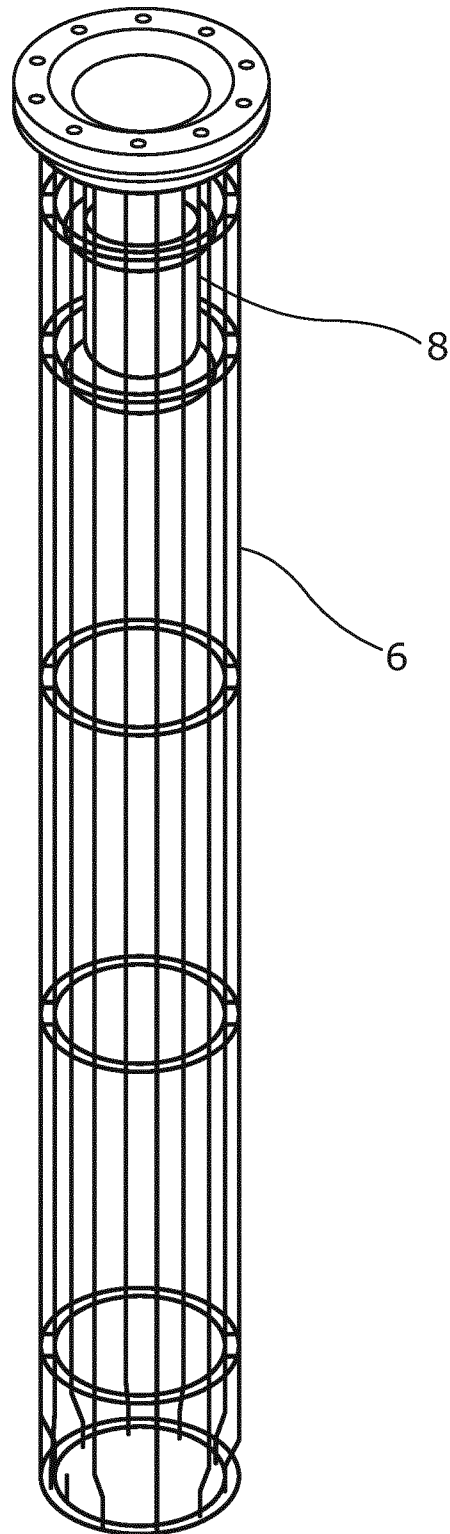


Figure 2

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2016/078628

A. CLASSIFICATION OF SUBJECT MATTER

INV. B01D46/00 B01D46/02
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)

B01D

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.
A	US 4 400 971 A (TASSICKER OWEN J [US]) 30 August 1983 (1983-08-30) abstract; figures 3,6,7 column 3, line 22 - column 4, line 20 -----	1-10
A	WO 2015/042960 A1 (SCHNEIDER ELECTRIC IT CORP [US]; GALSIM MARLON [CN]; APUHIN MARLOWE DU) 2 April 2015 (2015-04-02) abstract; figure 1 -----	1-10
A	CN 202 460 360 U (XIAOFENG WO) 3 October 2012 (2012-10-03) figure 1 -----	1-10
A	US 2007/084339 A1 (GRANT JOHN W [US] ET AL) 19 April 2007 (2007-04-19) abstract; figures 1,2 -----	1-10



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"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

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2016/078628

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