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(54) Title: PRESSURE MEASUREMENT

(57) Abstract: The present disclosure relates to a device for pressure measurement in a system 1. The device comprises a container 8 enclosing a volume, and a pressure sensor 7 arranged to detect a pressure in the enclosed volume. The container is provided with a plurality of openings, each opening being configured for allowing the enclosed volume to be in fluid communication with a respective pressure source 4.

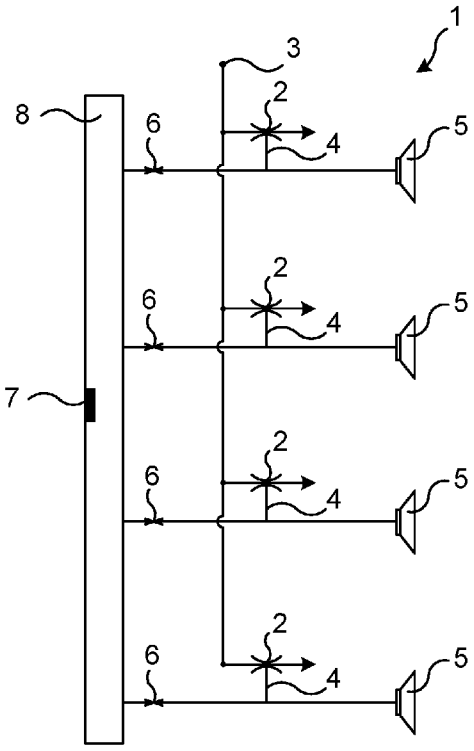

Fig. 3

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PRESSURE MEASUREMENT

TECHNICAL FIELD

The present disclosure relates to a device and method for pressure measurement in a system.

BACKGROUND

An ejector (also called e.g. aspirator, Venturi pump, ejector-jet pump, eductor-jet pump, injector, or thermocompressor, depending on type and use) may be used for sucking a gas out of a compartment to create a vacuum therein, typically by means of the Venturi effect. The Venturi effect is the reduction in fluid pressure that results when a fluid flows through a constricted section (or choke) of a pipe. This reduced pressure is used to suck out the gas. The fluid may be liquid, e.g. water (water aspirator), or gaseous, e.g. steam (steam ejector/injector) or compressed air.

An ejector may be used to create a vacuum for one or more suction cups to lift and transport objects e.g. in an industrial environment. The number of suction cups used depend on the size of the object to be lifted, or on the number of objects to be lifted at the same time e.g. from a conveyor belt.

An ejector may be connected to several suction cups, or each suction cup may be connected to a respective ejector. A vacuum source (such as an ejector) connected to several suction cups is often a cheaper solution, but with the drawback that if at least one of the suction cups is not in proper contact with the object to be lifted, the vacuum is spoiled also for the other suction cups connected to the same vacuum source. On the other hand, several vacuum sources, each connected to one or a group of suction cups, keeps the vacuum in the suction cups which are not connected to the same vacuum source as a leaking suction cup, but this is a more expensive solution. Also, in order to measure the vacuum in the suction cups, a sensor for each vacuum source is needed, further adding cost and complexity when a plurality of vacuum sources are used.

SUMMARY

It is an objective of the present invention to provide an improved device for pressure measurement in a system, e.g. overpressure or underpressure, solving or at least alleviating a problem with the prior art discussed above.

According to an aspect of the present invention, there is provided a device for pressure measurement in a system. The device comprises a container enclosing a volume, and a pressure sensor arranged to detect a pressure in the enclosed volume. The container is provided with a plurality of openings, each opening being configured for allowing the enclosed volume to be in fluid communication with a respective pressure source. The device may thus be connected to the pressure sources (e.g. ejectors or compressors) of the system to measure the pressure (e.g. vacuum or overpressure) therein by means of the (single) pressure sensor.

In some embodiments of the device, each opening is arranged with a restrictor, e.g. choke valve, to restrict the fluid flow between the pressure sources and the container, when the device is connected to the system.

According to another aspect of the present invention, there is provided a system comprising a plurality of pressure sources, a container enclosing a volume, and a pressure sensor arranged to detect a pressure in the enclosed volume. The container is connected to the pressure sources such that the enclosed volume is in separate fluid communication with each of said pressure sources.

According to another aspect of the present invention, there is provided a method for pressure measurement in a system. The method comprises detecting a pressure in an enclosed volume of a container in fluid communication with a plurality of pressure sources, and determining, based on the detected pressure, that at least one of the pressure sources is leaking. The method may be performed by means of the device aspect presented above.

In some embodiments of the method, the determining comprises determining, based on the detected pressure, how many of the plurality of pressure sources 4 are leaking. This is possible since the pressure in the container typically depends on the number of leaking pressure sources, e.g. how may suction cups are not properly attached to an object to lift.

In some embodiments, the container is in the form of a pipe. The pipe may typically be a thin pipe, to define a small enclosed volume, and may run in a longitudinal direction of the system e.g. along and close to a row of suction cups or pressure sources for easy connection thereto.

In some embodiments, the pressure sources are vacuum ports. In some embodiments, the vacuum ports are connected to at least one vacuum ejector as discussed herein, whereby the system further comprises said at least one vacuum ejector connected to the vacuum ports. Alternatively, the vacuum ports may be connected to anther type of vacuum pump. In some embodiments, a respective vacuum ejector, or other vacuum pump, is connected to each of the vacuum ports.

In some embodiments, the at least one vacuum pump, e.g. ejector, is in fluid communication with at least two, e.g. all, of the vacuum ports, providing vacuum for a group of vacuum ports. In some embodiments, each of the vacuum ports is connected to a suction cup. In some embodiments, the at least one vacuum ejector is connected to a compressed air source. Alternatively, the at least one vacuum ejector is connected to another compressed fluid, e.g. water or steam. In some embodiments, a plurality of the ejectors are connected to the same pressure source of the compressed fluid. In some other embodiments, each ejector is connected to a respective pressure source of the compressed fluid.

Alternatively, in other embodiments, the pressure sources are sources of overpressure e.g. compressed air, if an overpressure is desired instead of a vacuum. The pressure sources may e.g. comprise pressure ports connected to

compressors to provide an overpressure, in a corresponding way as e.g. ejectors provide a vacuum (underpressure) to a vacuum port pressure source.

Thus, in some other embodiments, the pressure sources are overpressure ports. In some embodiments, the overpressure ports are connected to at least one compressor or other overpressure pump, whereby the system further comprises said at least one compressor or other overpressure pump connected to the overpressure ports. In some embodiments, a respective compressor, or other overpressure pump, is connected to each of the overpressure ports. In some embodiments, the at least one overpressure pump, e.g. compressor, is in fluid communication with at least two, e.g. all, of the overpressure ports, providing overpressure for a group of overpressure ports.

By means of measuring the pressure in the container enclosing a volume, a leakage at any of the pressure sources can be determined without the need for a pressure sensor for each pressure source e.g. ejector, since all the pressure sources communicate with the enclosed volume. Only a single pressure sensor may be needed, reducing the cost and complexity of the system. It is noted that the leakage may be intentional, e.g. if an object to be lifted is not large enough to engage all suction cups. Also, the leakage does not have to be from side of the suction cup or corresponding element, but may in some cases be from the pressure source side, e.g. if an ejector or compressor is leaking.

It is to be noted that any feature of any of the aspects may be applied to any other aspect, wherever appropriate. Likewise, any advantage of any of the aspects may apply to any of the other aspects. Other objectives, features and advantages of the enclosed embodiments will be apparent from the following detailed disclosure, from the attached dependent claims as well as from the drawings.

Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means,

step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated. The use of "first", "second" etc. for different features/components of the present disclosure are only intended to distinguish the features/components from other similar features/components and not to impart any order or hierarchy to the features/components.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Fig 1 is a schematic side section of an embodiment of a system of the present invention.

Fig 2 is a schematic circuit diagram of an embodiment of a system of the present invention with a plurality of ejectors, each with a separate source of pressurized fluid.

Fig 3 is a schematic circuit diagram of another embodiment of a system of the present invention with a plurality of ejectors, each with a communal source of pressurized fluid.

DETAILED DESCRIPTION

Embodiments will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments are shown. However, other embodiments in many different forms are possible within the scope of the present disclosure. Rather, the following embodiments are provided by way of example so that this disclosure will be thorough and complete, and will fully convey the scope of the disclosure to those skilled in the art. Like numbers refer to like elements throughout the description.

Herein, examples are given with pressure sources in the form of vacuum ports connected to vacuum pumps in the form of ejectors. However, the

invention is also relevant for other pressure sources, including overpressure sources, and other pumps, e.g. compressors for overpressure sources.

Figure 1 illustrates an embodiment of a system 1 comprising a vacuum ejector 2 for providing a pressure source 4 in the form of a vacuum port. A pressure source 3 of a pressurized fluid, e.g. of pressurized air, flows past an opening to the vacuum port 4, sucking out the air (or other fluid) from the vacuum port. A suction cup 5 is mounted to the vacuum port 4. If the suction cup 5 sealingly engages e.g. a surface of an object to be lifted, a reduced pressure is formed in the suction cup and the vacuum port by means of the ejector 2.

In accordance with the present invention, the pressure source 4 is provided with an opening 6 via which the pressure source is in fluid communication with the container 8 which encloses a relatively small volume. The opening 6 between the pressure source and the container is preferably relatively small and may be provided with a restrictor, e.g. a choke valve, to restrict the area of the opening 6. Specifically, the opening 6 has preferably substantially smaller cross-sectional area than the main opening of the pressure source/vacuum port, e.g. connected to the suction cup 5. Thereby, the pressure in the volume enclosed by the container 8 changes to different levels (which may be distinct and known beforehand) depending on how many pressure sources connected to the container 8 are leaking (e.g. via the suction cup 5). The opening 6 may for instance have a cross-sectional area which is less than ten times smaller than the cross-sectional area of the main opening of the pressure source 4, e.g. less than one hundred times smaller.

A pressure sensor 7 is provided in the container 8 to measure the pressure therein.

Figures 2 and 3 illustrates two different embodiments of a system 1 with a plurality of ejectors 2 for vacuum ports. In figure 2, each ejector 2 is connected to a respective source of pressurized fluid (e.g. air), while in figure 3, a single source of pressurized fluid is connected to a plurality of ejectors 2.

In case of overpressure ports, the ejectors may be exchanged for e.g. compressors.

When there is no leakage, the pressure in the container 8 is the same as in the suction cups 5. When there is a leakage at one pressure source/vacuum port 4, e.g. because its corresponding suction cup 5 is not properly engage with an object surface, vacuum is not formed in that vacuum port and a fluid flow (air) will continuously pass through the opening 6 into the container 8. Other, non-leaking, vacuum ports 4 connected to the container 8 will compensate for this (small) flow into the container 8 by sucking the fluid out of the container 8 since the pressure inside the container is higher than in said other vacuum ports. This gives a difference in pressure level of the volume enclosed by container 8 which is higher than the difference in pressure level of the other vacuum ports. However, the pressure level in the other ports will rise slightly due to the leakage via the container, but this rise is kept low since the openings 6 are small and restrict the leakage via the container 8.

For each pressure source with is leaking, the pressure in the volume enclosed by container 8 is changed. Thus, by measuring the pressure in the container 8, it is possible to determine, not only that a pressure source 4 is leaking, but how many pressure sources are leaking. A relatively small volume enclosed by container 8 implies that the pressure therein changes rapidly and any leakage may be detected by the pressure sensor 7 with short or almost no delay. For instance, if the pressure sources are vacuum sources, an increased pressure as measured in the container 8 to different levels may indicate that, and how many, vacuum sources are leaking. Similarly, if the pressure sources are overpressure sources, a reduced pressure as measured in the container 8 to different levels may indicate that, and how many, overpressure sources are leaking.

The pressure sensor 7 may be connected to a control unit such that the control unit receives signals from the pressure sensor regarding the pressure it measures in the container 8. The control unit may then determine whether

the measured pressure is above or below a predetermined threshold, indicating a leakage. Also, further predetermined thresholds may allow the control unit to determine how many pressure sources are leaking.

There may be a predetermined pressure level which is required and if this level is not reached, the system may be turned off for maintenance or some other action may be performed in order to reach the required pressure level. For instance, the pressure in the volume enclosed by container 8 may be required to be below a maximum threshold and if the measured pressure reaches or passes this maximum threshold, indicating too much leakage (e.g. of too many vacuum ports) in the system for the system to be able to perform its task (e.g. lifting an object by means of suction cups 5). This may also be determined by the control unit. Similarly, especially in case of overpressure sources, the pressure in the volume enclosed by container 8 may be required to be above a minimum threshold and if the measured pressure reaches or passes this minimum threshold, indicating too much leakage (e.g. of too many overpressure ports) in the system for the system to be able to perform its task.

The present disclosure has mainly been described above with reference to a few embodiments. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the present disclosure, as defined by the appended claims.

CLAIMS

1. A device for pressure measurement in a system (1), the device comprising:

a container (8) enclosing a volume; and

a pressure sensor (7) arranged to detect a pressure in the enclosed volume;

wherein the container (8) is provided with a plurality of openings, each opening being configured for allowing the enclosed volume to be in fluid communication with a respective pressure source (4).

2. The device of claim 1, wherein each opening is arranged with a restrictor, e.g. choke valve (6).

3. The device of claim 1 or 2, wherein the container (8) is in the form of a pipe.

4. A system (1) comprising:

a plurality of pressure sources (4);

a container (8) enclosing a volume; and

a pressure sensor (7) arranged to detect a pressure in the enclosed volume;

wherein the container (8) is connected to the pressure sources (4) such that the enclosed volume is in separate fluid communication with each of said pressure sources.

5. The system of claim 4, wherein the pressure sources (4) are vacuum ports.

6. The system of claim 5, further comprising at least one vacuum ejector (2) connected to the vacuum ports (4).

7. The system of claim 6, wherein the at least one vacuum ejector (2) is in fluid communication with at least two, e.g. all, of the vacuum ports (4).

8. The system of claim 6 or 7, wherein each of the vacuum ports (4) is connected to a suction cup (5).

9. The system of any claim 6-8, wherein the at least one vacuum ejector (2) is connected to a compressed air source (3).

10. The system of claim 4, wherein the pressure sources (4) are overpressure ports.

11. The system of claim 10, further comprising at least one compressor connected to the overpressure ports.

12. The system of claim 11, wherein the at least one compressor is in fluid communication with at least two, e.g. all, of the overpressure ports.

13. A method for pressure measurement in a system (1), the method comprising:

detecting a pressure in an enclosed volume of a container (8) in fluid communication with a plurality of pressure sources (4); and

determining, based on the detected pressure, that at least one of the pressure sources (4) is leaking.

14. The method of claim 13, wherein the determining comprises determining, based on the detected pressure, how many of the plurality of pressure sources (4) are leaking.

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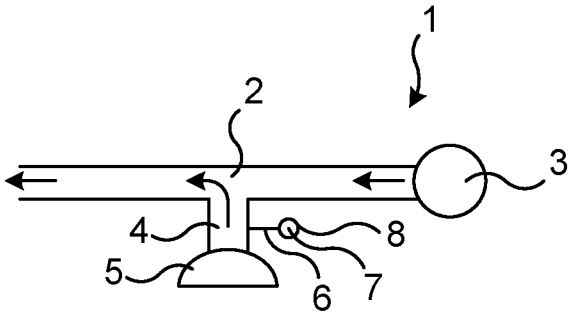

Fig. 1

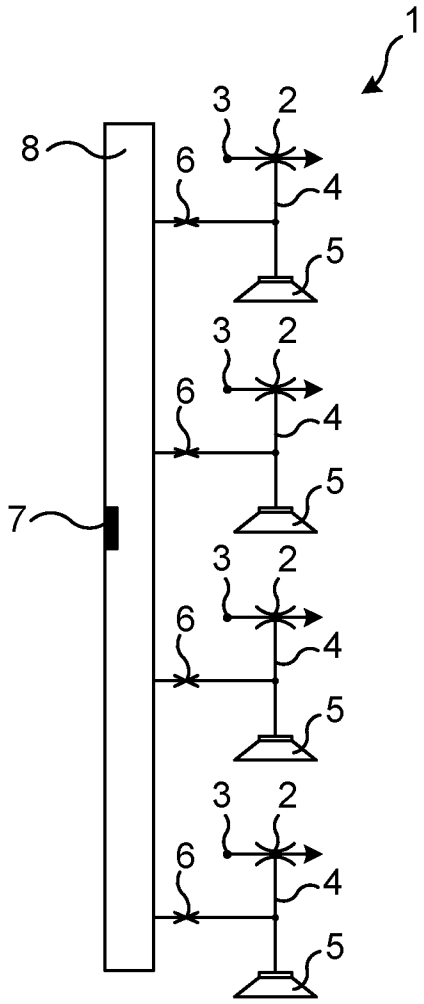

Fig. 2

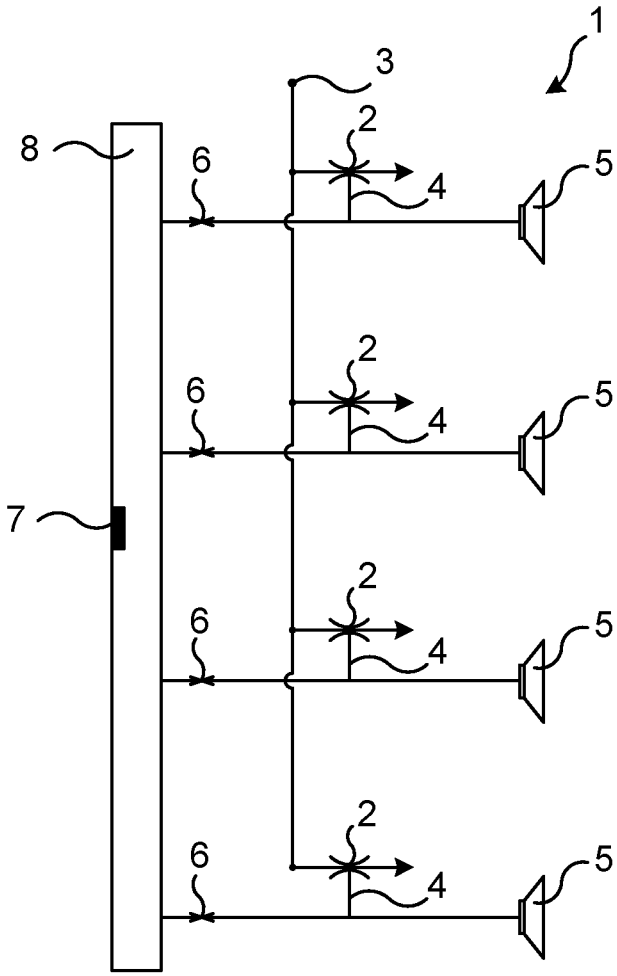

Fig. 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2017/050110

A. CLASSIFICATION OF SUBJECT MATTER

IPC: see extra sheet

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)

IPC: B66C, G01M

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)

EPO-Internal, PAJ, 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	DE 10009167 A1 (FESTO AG & CO), 13 September 2001 (2001-09-13); abstract; figure 1 --	1-14
A	DE 19639263 A1 (SCHMIDT WERNER), 26 March 1998 (1998-03-26); abstract --	1-14
A	DE 4106916 C1 (BARTHOLOMY & CO), 25 June 1992 (1992-06-25); abstract; figure 1 --	1-14
A	EP 1775243 A2 (TRUMPF MASCHINEN AUSTRIA GMBH), 18 April 2007 (2007-04-18); abstract; figures 1,3 --	1-14

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"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
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE2017/050110

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 9205558 B1 (ZEVENBERGEN JOHN ET AL), 8 December 2015 (2015-12-08); abstract; figures 4a-4d -- --------	1-14

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				KR	20170013925	A	07/02/2017
				WO	2016010968	A1	21/01/2016

International application No.
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Continuation of: second sheet

International Patent Classification (IPC)

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G01M 3/26 (2006.01)