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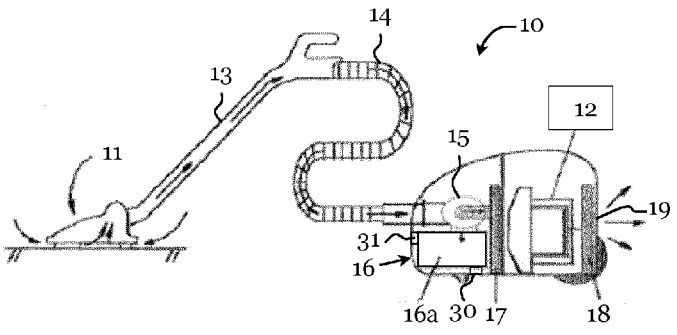


Figure 3a

(57) Abstract: The present disclosure relates to a vacuum cleaner (10) comprises a dust compartment (16), the vacuum cleaner further comprising a vibration sensor (30) configured to measure vibrations of the dust compartment (16) and to produce an output signal representing the measured vibrations, and a controller (31) being configured to receive said output signal and to determine from the output signal a degree of filling of the dust compartment (16), wherein a lower vibration indicates a higher degree of filling of the dust compartment (16).

WO 2020/165154 A1

MEASURING DUST COMPARTMENT FILLING DEGREE OF A VACUUM CLEANER

TECHNICAL FIELD

[001] The present disclosure relates to a vacuum cleaner comprising a dust compartment.

BACKGROUND

[002] When buying a vacuum cleaner, a consumer has the option of selecting a bag vacuum cleaner or a bagless vacuum cleaner.

[003] There are also different types of bagged and bagless vacuum cleaners such as upright, stick based, handheld, canister even robotic vacuum cleaners. Commonly, a bagless vacuum cleaner utilizes a cyclonic effect to separate dust from the airflow and a bagged vacuum cleaner uses an air permeable dustbag to separate the dust from the airflow.

[004] A problem with vacuum cleaners, whether they are bagless or not, is the difficulty of determining whether a dustbin or dustbag of the vacuum cleaner is full or not, or the degree of filling. Infrared (IR) sensors have been used to determine a filling degree of the dustbin. The IR sensor transmits infrared light, which is detected by a photo sensor/receiver. The amount of light detected by the photo sensor decreases when there are more particles in the air between the IR transmitter and a photo sensor, which can be analysed to determine if the dustbin is full. However, an IR sensor has a slow response, and is not very accurate for this purpose. For instance, the IR sensor could erroneously detect that the dustbin is full if dust temporarily is gathered at the photo sensor. Pressure sensors have been used to determine a filling degree of the dustbag, but require pressure sensing in different places and may interfere with the airflow.

SUMMARY

[005] One objective is to solve, or at least mitigate, this problem in the art and thus to provide an improved vacuum cleaner for determining a filling degree of the dust compartment of the vacuum cleaner.

[006] This objective is attained in an aspect of the invention by a vacuum cleaner comprising a dust compartment, which vacuum cleaner further comprises a vibration

sensor configured to measure vibrations of the dust compartment and to produce an output signal representing the measured vibrations, and a controller being configured to receive said output signal and to determine from the output signal a degree of filling of the dust compartment, wherein a lower vibration indicates a higher degree of filling of the dust compartment.

[007] In embodiments, the dust compartment may comprise a dustbin, preferably removable from the vacuum cleaner or a dustbag, preferably removably arranged in a holder in the dust compartment.

[008] Hence, a vibration sensor is configured to measure vibrations of the dust compartment and to produce an output signal representing the measured vibrations. This output signal is supplied to a controller, which determines from the output signal a degree of filling of the dustbin or dustbag; a greater vibration indicates a lower degree of filling of the dustbin/dustbag while a lower vibration indicates a higher degree of filling of the dustbin/dustbag.

[009] In an embodiment, the controller is further configured to determine from the output signal representing the measured vibrations that a particular measured value of vibration represents a corresponding degree of filling of the dust compartment.

[0010] In an embodiment, the controller is further configured to access a look-table where, for a plurality of measured vibration values, a predetermined degree of filing is associated with each of said plurality of measured vibration values.

[0011] In an embodiment, the vibration sensor comprises an accelerometer.

[0012] In an embodiment, the controller being configured to receive an output signal for each axis of the accelerometer representing the vibrations measured along each axis.

[0013] In an embodiment, the controller is configured to determine, from the output signals, a degree of filling of the dust compartment if at least two of the accelerometer axes indicate the same filling degree, in which case the filling degree of the dustbin is determined to be the filling degree indicted by said at least two axes.

[0014] In an embodiment, the vacuum cleaner further comprises a noise sensor configured to measure an overall noise level of the vacuum cleaner and to produce an output signal representing the measured noise level, wherein the controller is configured to receive the output signal of the noise sensor and to determine from the

output signal a degree of filling of the dust compartment, wherein a lower noise level indicates a higher degree of filling of the dust compartment.

[0015] In an embodiment, the controller is further configured to access a look-table where for a plurality of measured noise levels, a predetermined degree of filing is associated with each of said plurality of measured noise levels.

[0016] In an embodiment, the controller is further configured to determine the filing degree if the vibration sensor and the noise sensor indicate the same filling degree.

[0017] In an embodiment, the noise sensor comprises a microphone.

[0018] In an embodiment, the controller is further configured to present the determined filling degree of the dust compartment on a user interface of the vacuum cleaner.

[0019] In an embodiment, the controller is further configured to determine from the output signal a resonant frequency of the dust compartment, wherein a lower resonant frequency indicates a higher degree of filling of the dust compartment.

[0020] In an embodiment, the resonant frequency is determined to be the frequency where a magnitude of vibration of the dustbin reaches a maximum value.

[0021] In an embodiment, the dustbin is elastically arranged inside the dust compartment.

[0022] In an embodiment, the dustbin is attached to the dust compartment via at least one spring.

[0023] In an embodiment the vacuum cleaner further comprises a magnet arranged inside the dustbin and a magnetic field sensor arranged outside the dustbin in proximity to the magnet, the magnetic field sensor being arranged to detect the vibration of the dust bin.

[0024] In an embodiment, the controller is arranged to perform a frequency sweep by increasing or decreasing the speed of a motor in the vacuum cleaner.

[0025] In an embodiment, the controller is further configured to determine from the output signal a magnitude of vibration of the dust compartment wherein a lesser magnitude indicates a higher degree of filling of the dust compartment.

[0026] In an embodiment, the controller is configured to detect a first peak in the magnitude of vibration of the dust compartment at a first vibrational frequency of the dust compartment and detect a second peak in the magnitude of vibration of the dust compartment at a second vibrational frequency of the dust compartment, wherein a higher ratio between the first and second peak indicates a higher degree of filling of the dust compartment.

[0027] In a further aspect, a vacuum cleaner is provided comprising a dust compartment, a microphone configured to measure sound in the dust compartment and to produce an output signal representing the measured sound, and further a controller being configured to receive said output signal and to determine from the output signal a degree of filling of the dust compartment, wherein a lower level of the measured sound indicates a higher degree of filling of the dust compartment.

[0028] 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.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Aspects and embodiments are now described, by way of example, with reference to the accompanying drawings, in which:

[0030] Figure 1 shows a prior art vacuum cleaner in which embodiments may be implemented;

[0031] Figure 2 shows a prior art cyclone which may be used in a bagless vacuum cleaner;

[0032] Figure 3a shows a bagless vacuum cleaner comprising a vibration sensor according to an embodiment;

[0033] Figure 3b shows a bagged vacuum cleaner comprising a vibration sensor according to an embodiment;

[0034] Figure 4 shows a vacuum cleaner comprising a user interface according to an embodiment;

[0035] Figure 5 shows a vacuum cleaner comprising a noise sensor according to an embodiment:

[0036] Figure 6 illustrates a further embodiment of determining filling degree of a dust compartment;

[0037] Figure 7 illustrates determining filling degree of a dust compartment in a further embodiment;

[0038] Figure 8 illustrates a sensor arrangement for measuring the resonant frequency of the dustbin in an embodiment;

[0039] Figure 9 illustrates a sensor arrangement for measuring the resonant frequency of the dustbin in another embodiment;

[0040] Figure 10 illustrates a microphone arrangement for determining filling degree of a dust compartment in an embodiment; and

[0041] Figure 11 illustrates determining filling degree of a dust compartment in a further embodiment.

DETAILED DESCRIPTION

[0042] The aspects of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown.

[0043] These aspects may, however, be embodied in many different forms and should not be construed as limiting; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and to fully convey the scope of all aspects of invention to those skilled in the art. Like numbers refer to like elements throughout the description.

[0044] Figure 1 illustrates prior art bagless canister vacuum cleaner 10 in which embodiments may be implemented.

[0045] The vacuum cleaner 10 comprises a nozzle 11 via which dust and debris are removed from a surface to be cleaned by means of a motor fan unit 12 creating an

airflow via which the dust is transported via a suction pipe 13 and a tube 14 to a cyclone 15 where the dust is separated from the airflow and enters a dust compartment 16 comprising a dustbin 16a while the cleaned air is transported via a pre-filter 17 and possibly also an exhaust filter 18 before exiting the vacuum cleaner via an outlet 19.

[0046] Figure 2 illustrates the basic working principle of a so called reverse cyclone 15 which may be used in the vacuum cleaner 10 of Figure 1. A reverse cyclone 15 has one inlet 21 and two outlets 22, 23. Dust laden air enters inlet 21 and is caught up in a vortex 20 created in the cyclone 15. The vortex 20 will transport the dust particles via first outlet 22 to the dustbin 16a of Figure 1, while the cleaned air is transported to second outlet 22 where it exits the cyclone 15 and passes through the pre-filter 17 illustrated in Figure 1.

[0047] Now, as previously has been discussed, a filling degree of the dustbin 16a needs to be determined such that a user can be informed accordingly, for instance by means of an indication on the vacuum cleaner 10.

[0048] Figure 3a illustrates the vacuum cleaner 10 of Figure 1, but where the cleaner 10 has been equipped with a vibration sensor 30 being attached to the dustbin 16a, or to the dust compartment 16, according to an embodiment, or at least arranged at an appropriate location in the vacuum cleaner 10 such that vibrations of the dust compartment 16 can be sensed. It may be envisaged that the vibration sensor 30 is attached to the cyclone 15, since the cyclone 15 has a tendency of vibrating more if the dustbin 16a is empty and less if the dustbin 16a is full, the same also applies to the dustbin and the whole vacuum cleaner.

[0049] Further, the vibration sensor 30 is communicatively coupled to a controller 31 (which already may be available in the vacuum cleaner 10 for controlling purposes).

[0050] The vibration sensor 30 is configured to measure vibrations of the dustbin 16a and to produce an output signal representing the measured vibrations. This output signal is supplied to the controller 31, which determines from the output signal a degree of filling of the dustbin 16a; a greater vibration indicates a lower degree of filling of the dustbin while a lower vibration indicates a higher degree of filling of the dustbin.

[0051] Advantageously, this overcomes the problems of using an IR sensor, since the vibrational frequency of the dustbin 16a is not affected by any temporary whirl of dust in the dustbin 16a.

[0052] Figure 3b illustrates a vacuum cleaner 10 comprising a dust compartment 16 accommodating a dustbag 16b (in which case a cyclone is not utilized). Again, the vacuum cleaner 10 comprises a nozzle 11 via which dust and debris are removed from a surface to be cleaned by means of a motor fan unit 12 creating an airflow via which the dust is transported via a suction pipe 13 and a tube 14 to the dust compartment 16 and into a dustbag 16b where the dust is separated from the airflow and stays in the dustbag 16b while the cleaned air is transported via a pre-filter 17 and possibly also an exhaust filter 18 before exiting the vacuum cleaner via an outlet 19.

[0053] Further, the vibration sensor 30 is communicatively coupled to a controller 31 (which already may be available in the vacuum cleaner 10 for controlling purposes).

[0054] The vibration sensor 30 is configured to measure vibrations of the dust compartment 16 and to produce an output signal representing the measured vibrations. This output signal is supplied to the controller 31, which determines from the output signal a degree of filling of the dustbag 16b; a greater vibration of the dust compartment 16 indicates a lower degree of filling of the dustbag 16b while a lower vibration indicates a higher degree of filling of the dustbag 16b.

[0055] Advantageously, this overcomes a problem in the art for bag vacuum cleaners using a pressure sensor, which may be an inaccurate approach of measuring filling degree.

[0056] In an embodiment, for a particular vacuum cleaner model, different filling degree of the dustbin 16a or dustbag 16b and the corresponding vibrational frequencies are recorded during manufacturing or in a pre-manufacturing test. It is noted that different models typically will give rise to different vibrational frequencies.

[0057] Now, assuming that the vibration sensor 30 measures the vibrational frequency to be A Hz when the dustbin 16a or dustbag 16b is completely empty, B Hz when the dustbin 16a or dustbag 16b has a filling level of 20%, and so on, until the dustbin 16a or dustbag 16b is completely full which corresponds to a vibrational frequency of F Hz, where the vibrational frequency decreases as the dustbin 16a or dustbag 16b fills up.

Vibrational frequency (Hz)	Filling degree (%)
A	0
B	20
C	40
D	60
E	80
F	100

Table 1. Vibrational frequency vs. dustbin/dustbag filling degree

[0058] Thus, when the vibration sensor 30 measures the vibrational frequency of the dustbin 16a or dustbag 16b to be C Hz, the controller 31 concludes, by reading the sensor measurement and turning to for instance a look-up table comprising the information of Table 1, that the dustbin 16a or dustbag 16b is filled up to 40%, which may be displayed to the user on a user interface of the vacuum cleaner 10.

[0059] The resolution may be different than that exemplified in Table 1. For instance, it may be envisaged that only a situation where the dustbin 16a or dustbag 16b is full is signalled to the user, or when the dustbin 16a or dustbag 16b is close to being full, for instance at an 80% filling degree.

[0060] Figure 4 illustrates the vacuum cleaner 10 in a top view where a main body 32 of the vacuum cleaner 10 comprises a graphical user interface 33 on its upper side, where the controller 31 indicates visually to the user that the filling degree of the dustbin 16a or dustbag 16b has reached 80%.

[0061] In an embodiment, the vibration sensor 30 is implemented in the form of an accelerometer, for instance a microelectromechanical systems (MEMS) accelerator.

[0062] In a further embodiment, with reference to Figure 5, the vacuum cleaner 10 (in this case illustrated with the bagless cleaner, but can also be implemented in a bagged vacuum cleaner) is optionally equipped with a noise sensor 34 for measuring

noise caused by the vacuum cleaner 10 itself, mainly by the fan motor unit 12. The overall level of noise caused by the vacuum cleaner 10 is affected by the filling degree of the dustbin 16a; a full dustbin has a tendency of being sound-absorbing. As a result, a lower overall noise level of the vacuum cleaner 10 would imply a higher filling degree of the dustbin 16a. Further, the noise caused by cyclonic swirl of the cyclone 15 is less absorbed by the dustbin 16 when the dustbin has a low filling degree, thereby adding to the overall noise level of the vacuum cleaner 10. The noise sensor 34 is communicatively coupled to the controller 31.

[0063] Even though manually operated vacuum cleaners have been described, the invention could advantageously be implemented in a robotic vacuum cleaner.

[0064] Such noise sensor 34 may be embodied in the form of an accelerator, a microphone or any appropriate sensor capable of measuring a noise level, which is arranged at an appropriate location in the vacuum cleaner 10.

[0065] Similar to the vibration sensor 30, the noise sensor 34 measures the overall noise level to be G dB when the dustbin 16 is completely empty, H dB when the dustbin 16a has a filling level of 20%, and so on, until the dustbin 16a is completely full which corresponds to a noise level of L dB, where the noise level decreases as the dustbin 16a fills up.

Noise level (dB)	**Filling degree (%)**
G	0
H	20
I	40
J	60
K	80
L	100

Table 2. Noise level vs. dustbin/dustbag filling degree

[0066] Thus, when the noise sensor 34 measures the overall noise level of the vacuum cleaner 10 to be I Hz, the controller 31 concludes, by reading the noise sensor measurement and turning to for instance a look-up table comprising the information of Table 2, that the dustbin 16a is filled up to 40%, which may be displayed to the user on a user interface of the vacuum cleaner 10.

[0067] Now, by combining the reading of the noise sensor 34 with the reading of the vibration sensor 30, the controller 31 is advantageously ensured that the determined filling degree is likely to be accurate; if both sensors indicate that the filling degree is, say, 40%, then the determination will be considered accurate.

[0068] To the contrary, should the two sensors 30, 34 indicate different filling degrees, it may be advisable to perform further measurements before the controller 31 displays a determined filling degree to the user.

[0069] A similar advantage may be attained in case of using an accelerometer as a vibration sensor 30; since the accelerometer has an X-, Y and Z-axis, the vibrational frequency of the dustbin 16 can be measured along of these three axes, and if all three measurements indicates a similar filling degree, the controller 31 will consider the measurements to be accurate. It may be envisaged that a look-up table such as that illustrated in Table 1 is formed for each axis of the accelerometer, and that the controller 31 determines the filling degree of the dustbin 16 based on measurements along one axis, two axes or all three axes of the accelerometer.

[0070] In practice, it may also be that one of the three accelerometer axes presents a more accurate measurement of the vibrational frequency of the dustbin 16a than the other two axes, in which case the determination by the controller 31 may rely on the measurement of that sole axis.

[0071] Further, by performing a Fast Fourier Transform (FFT) on the measured acceleration values, peak value(s) of the result of the FFT will indicate the vibration frequency of the object for which the measurement is made (i.e. the dustbin 16a or the dustbag 16b).

[0072] Figure 6 illustrates a further embodiment of determining filling degree of a dust compartment.

[0073] In this embodiment, the dustbin 16a is elastically arranged in the dust compartment 16 of the vacuum cleaner 10, for instance via a suspension attachment formed by one or more springs 24.

[0074] When the vacuum cleaner is in operation, the main body 32 of the vacuum cleaner (and thus the dust compartment 16) will vibrate with amplitude A_{IN} at frequency f_{IN}, mainly caused by the previously described motor fan unit 12. The spring-suspended dustbin 16a will accordingly vibrate at frequency f_{OUT} with amplitude A_{OUT}, which will depend on the filling degree of the dustbin 16a.

[0075] Now, at the resonant frequency f_0 of the dustbin 16a, the relation between the magnitude A_{OUT} of the vibration of the dustbin 16a and the magnitude A_{IN} of the vibration of the main body 32 will be at its maximum, since the dustbin 16a will vibrate at its maximum at resonance.

[0076] As illustrated in Figure 7, the maximum value of A_{OUT}/A_{IN} will occur at a higher resonant frequency f_0 of the main body 32 of the vacuum cleaner 10 dustbin 16a when the dustbin 16a is empty, as compared to the resonant frequency f_0 where the maximum value of A_{OUT}/A_{IN} occurs with the dustbin 16a being full. Thus, as the dustbin 16a fills up, the resonant frequency f_0 of the vacuum cleaner 10 will decrease.

[0077] In order to find the resonant frequency f_0 of the vacuum cleaner 10 for a full dustbin 16a, the vibrational frequency f_{IN} of the vacuum cleaner may be swept for instance by increasing the speed of the motor fan unit 12 from 0 up to X rpm, or by decreasing the speed from X rpm to 0. This may be performed when the vacuum cleaner is turned on or as a dedicated filling degree detection procedure. Alternatively, other motors such as those driving brushes or the wheel motors of a robotic vacuum cleaner, could be used to excite vibrations at desired frequencies.

[0078] The particular resonant frequencies f_0 of a full and empty dustbin 16a, respectively, may be determined during a manufacturing test of the vacuum cleaner and stored in a memory of the controller 31 for use during normal operation of the vacuum cleaner 10. It is noted that such a test typically only is necessary to perform for a single individual of a particular vacuum cleaner model. It may alternatively be envisaged that the resonant frequencies f_0 of a full and/or empty dustbin 16a can be determined during use, at a time when the user has just emptied the dustbin 16a, so it can be assumed to be

empty, or if the user in some way indicates that the dustbin 16a is full, so this can be assumed to be true.

[0079] During the frequency sweep, the controller 31 registers a maximum value of the vibration A_{OUT} of the dust bin 16a occurring at a particular resonant frequency f_0 with a full dustbin 16a. It may alternatively be envisaged that the sweep is performed with an empty dustbin 16a if the resonant frequency f_0 with the empty dustbin 16a is located at a known frequency offset from the corresponding resonant frequency f_0 with the dustbin 16a being full.

[0080] As a result, the controller 31 is made aware of the resonant frequency f_0 of the vacuum cleaner 10 when the dustbin 16a is full.

[0081] Thus, the controller 31 may during operation of the vacuum cleaner 10 perform a brief frequency sweep, for instance by increasing the speed of the motor fan unit 12 and during the sweep measure the vibration A_{OUT} of the dustbin 16a. If the controller 31 registers a maximum value of A_{OUT} at or close to the previously registered "full dustbin" resonant frequency f_0, the dustbin 16a is full (or close to full), which is indicated accordingly to a user (for instance via the display 33 illustrated in Figure 4).

[0082] It should be noted that the amplitude of the vibration A_{IN} of the vacuum cleaner is generally independent of the filling degree of the dustbin 16a. In practice, it is thus sufficient to measure the vibration amplitude A_{OUT} of the dustbin 16a.

[0083] Figure 8 illustrates a sensor arrangement for measuring the resonant frequency f_0 of the dustbin 16a comprising a magnet 25 being located in the dustbin 16a and a Hall effect sensor 26 being arranged in proximity to the magnet 25 in the vacuum cleaner 10. The Hall effect sensor could alternatively be replaced by an electromagnetic coil or another sensor for static or dynamic magnetic field strength.

[0084] The Hall effect sensor 26 may both detect presence of magnet 25 (and thus the dustbin 16a) and the magnitude A_{OUT} of the vibration of the dustbin 16a. The controller 31 will conclude that when the Hall effect sensor measures a maximum value of the vibration A_{OUT} of the dustbin 16 at frequency corresponding to "f_0 at full" in Figure 7, the dust compartment 16 is full, and an indication may be given to the user.

[0085] Figure 9 illustrates a further embodiment of determining filling degree of a dust compartment. In this embodiment, the magnet 25 is elastically arranged in the

dustbin 16a for instance via a suspension attachment formed by one or more springs 24. Using for instance the Hall effect sensor 26 (or a coil) to measure vibrations A_{OUT} of the magnet 25, the filling degree of the dustbin 16a may be determined, since the magnitude of the vibrations will decrease as the compartment 16 fills up with dust. It may be envisaged that when the magnitude A_{OUT} of the vibrations falls to a (low) predetermined value, the dustbin 16a is considered to be full.

[0086] As previously has been mentioned, a noise sensor in the form of a microphone may be arranged at an appropriate location in the vacuum cleaner. For instance, in an embodiment illustrated in Figure 10, the microphone 27 may be arranged inside the dustbin 16a (or inside the dust compartment 16 in case no dustbin 16a is used). The sound detected by the microphone 27 will be attenuated as the dustbin 16a fills up with dust. It may thus be envisaged that when the level of the sound detected by the microphone falls to a (low) predetermined value, the dustbin 16a is considered to be full as detected by the controller 31 receiving a signal representing the measured sound from the microphone 27.

[0087] In still a further embodiment, the measured vibration of dust compartment 16 (which may or may not comprise a dustbin 16a), could be represented in the frequency domain as illustrated in Figure 11. Such a frequency domain representation can, as one example, be found by applying the Fast Fourier Transform. The frequency domain representation could contain a number of amplitude peaks such as a first peak A_1 at a first frequency f_1 and a second peak A_2 at a second frequency f_2. These peaks appear to occur at rather consistent frequencies, such as the first occurring at a frequency f_1 around 300 Hz and the second occurring at a frequency f_2 around 900 Hz (dependent on the particular model of the vacuum cleaner 10) when the vacuum cleaner 10 is running at its nominal speed.

[0088] Now, in case the dust compartment 16 (or dustbin 16a) is full, the amplitude A_1 of the first peak is much larger than the amplitude A_2 of the second peak. Measurements show that the ratio A_1/A_2 is just over 20 dB – around 21.5 dB - when the dustbin 16a is full.

[0089] To the contrary, if the dustbin is empty, the ratio A_1/A_2 is just under 5 dB – around 4.65 dB.

[0090] Thus, if it can be concluded that the measured ratio A_1/A_2 is above 21.5 – 4.65 = 16.82 dB, it can be concluded that the dustbin 16a is full. In practice, a threshold value may be set to around 17 dB, and if the ratio A_1/A_2 exceeds the threshold value, the dust bin 16a/dust compartment 16 is indicated to be full.

[0091] The aspects of the present disclosure have mainly been described above with reference to a few embodiments and examples thereof. 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 invention, as defined by the appended patent claims.

CLAIMS

1. A vacuum cleaner (10) comprising a dust compartment (16), the vacuum cleaner further comprising:

a vibration sensor (30) configured to measure vibrations of the dust compartment (16) and to produce an output signal representing the measured vibrations; and

a controller (31) being configured to receive said output signal and to determine from the output signal a degree of filling of the dust compartment (16), wherein a lower vibration indicates a higher degree of filling of the dust compartment (16).

2. The vacuum cleaner (10) of claim 1, the controller (31) further being configured to:

determine from the output signal representing the measured vibrations that a particular measured value of vibration represents a corresponding degree of filling of the dust compartment (16).

3. The vacuum cleaner (10) of claim 2, the controller (31) further being configured to access a look-table where, for a plurality of measured vibration values, a predetermined degree of filing is associated with each of said plurality of measured vibration values.

4. The vacuum cleaner (10) of any one of the preceding claims, the vibration sensor (30) comprising an accelerometer.

5. The vacuum cleaner (10) of claim 4, the controller (31) being configured to receive an output signal for each axis of the accelerometer representing the vibrations measured along each axis.

6. The vacuum cleaner (10) of claim 5, the controller (31) being configured to determine, from the output signals, a degree of filling of the dust compartment (16) if at least two of the accelerometer axes indicate the same filling degree, in which case the filling degree of the dustbin is determined to be the filling degree indicted by said at least two axes.

7. The vacuum cleaner (10) of any one of the preceding claims, further comprising:

a noise sensor (34) configured to measure an overall noise level of the vacuum cleaner (10) and to produce an output signal representing the measured noise level;

wherein

the controller (30) is configured to receive the output signal of the noise sensor (34) and to determine from the output signal a degree of filling of the dust compartment (16), wherein a lower noise level indicates a higher degree of filling of the dust compartment (16).

8. The vacuum cleaner (10) of claim 7, the controller (31) further being configured to access a look-table where for a plurality of measured noise levels, a predetermined degree of filing is associated with each of said plurality of measured noise levels.

9. The vacuum cleaner (10) of claims 7 or 8, the controller (31) further being configured to determine the filing degree if the vibration sensor (30) and the noise sensor (34) indicate the same filling degree.

10. The vacuum cleaner (10) of claims 7 or 8, the noise sensor (34) comprising a microphone.

11. The vacuum cleaner (10) of any one of the preceding claims, the controller (31) further being configured to present the determined filling degree of the dust compartment (16) on a user interface (33) of the vacuum cleaner (10).

12. The vacuum cleaner (10) of any one of the preceding claims, the dust compartment (16) being configured to accommodate a removable dustbag (16b).

13. The vacuum cleaner (10) of claim 12, the dust compartment (16) comprising a holder and the dustbag (16b) being arranged with a collar adapted to be removably arranged in the holder.

14. The vacuum cleaner (10) of any one of the claims 1-11, the dust compartment (16) comprising a removable dustbin (16a).

15. The vacuum cleaner (10) of any one of the preceding claims, the controller (31) further being configured to:

determine from the output signal a resonant frequency of the dust compartment (16), wherein a lower resonant frequency indicates a higher degree of filling of the dust compartment (16).

16. The vacuum cleaner (10) of claims 14 and 15, wherein the resonant frequency is determined to be the frequency where a magnitude of vibration of the dustbin (16a) reaches a maximum value.

17. The vacuum cleaner (10) of claim 16, the dustbin (16a) being elastically arranged inside the dust compartment (16).

18. The vacuum cleaner (10) of claim 17, the dustbin (16a) being attached to the dust compartment (16) via at least one spring (24).

19. The vacuum cleaner (10) of claim 14, further comprising a magnet (25) arranged inside the dustbin (16a) and a magnetic field sensor (26) arranged outside the dustbin (16a) in proximity to the magnet (25), the magnetic field sensor (26) being arranged to detect the vibration of the dust bin (16a).

20. The vacuum cleaner (10) of any one of claims 15-19, the controller (31) being arranged to perform a frequency sweep by increasing or decreasing the speed of a motor in the vacuum cleaner (10).

21. The vacuum cleaner (10) of any one of claims 1-14, the controller (31) further being configured to:

determine from the output signal a magnitude of vibration of the dust compartment (16) wherein a lesser magnitude indicates a higher degree of filling of the dust compartment (16).

22. The vacuum cleaner (10) of claim 20, the controller (31) further being configured to:

detect a first peak in the magnitude of vibration of the dust compartment (16) at a first vibrational frequency of the dust compartment and detect a second peak in the magnitude of vibration of the dust compartment (16) at a second vibrational frequency of the dust compartment (16), wherein a higher ratio between the first and second peak indicates a higher degree of filling of the dust compartment (16).

23. A vacuum cleaner (10) comprising a dust compartment (16), the vacuum cleaner further comprising:

a microphone (27) configured to measure sound in the dust compartment (16) and to produce an output signal representing the measured sound; and

a controller (31) being configured to receive said output signal and to determine

from the output signal a degree of filling of the dust compartment (16), wherein a lower level of the measured sound indicates a higher degree of filling of the dust compartment (16).

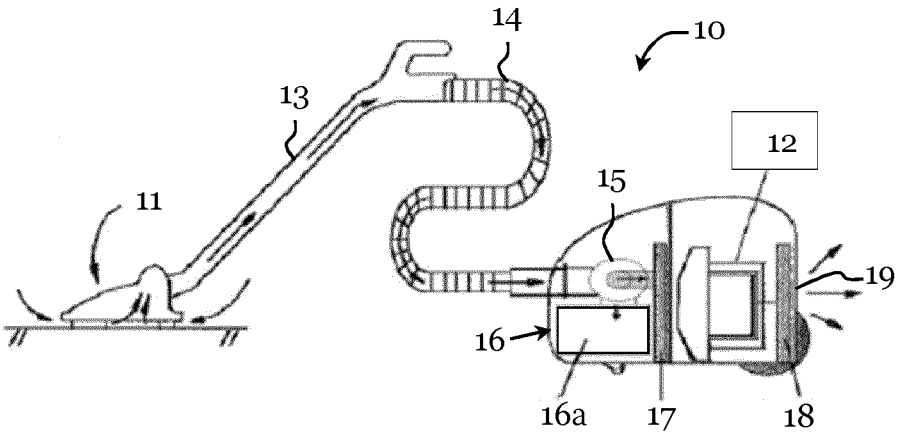


Figure 1

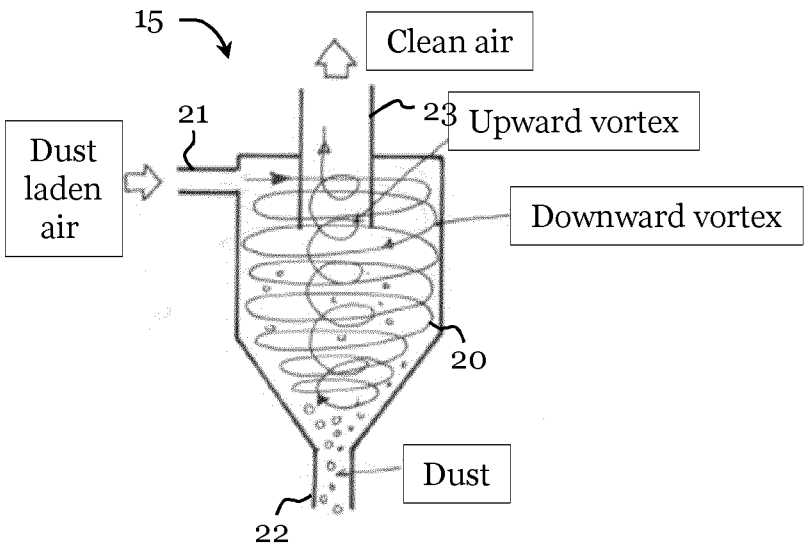


Figure 2

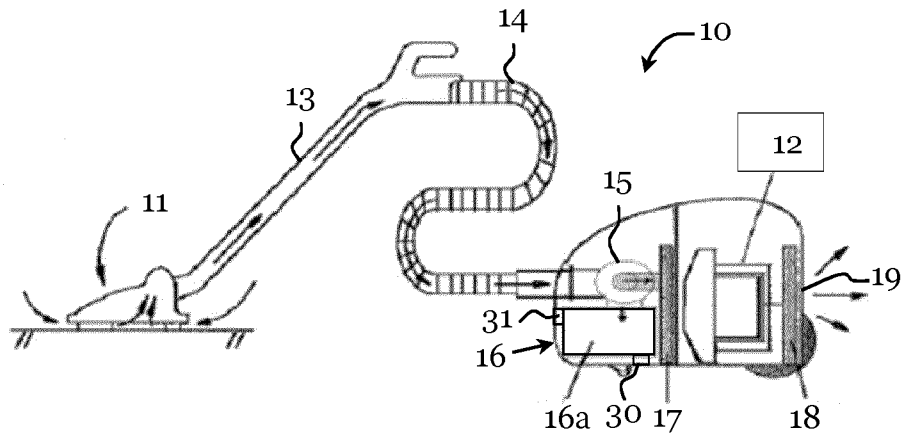


Figure 3a

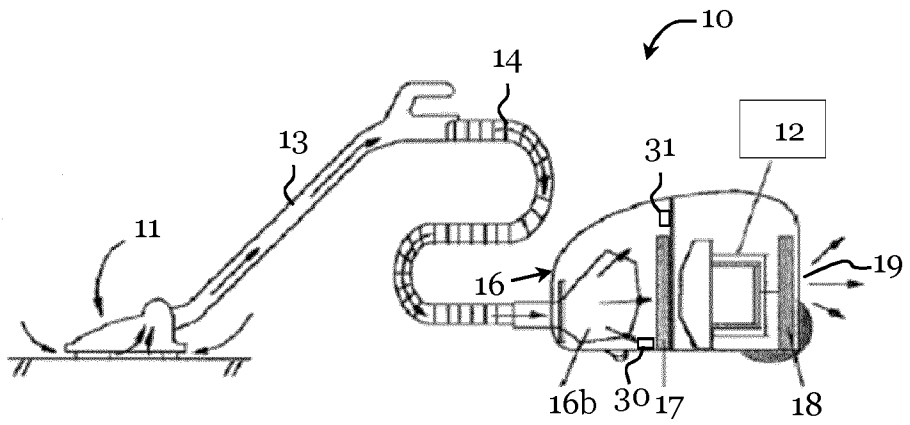


Figure 3b

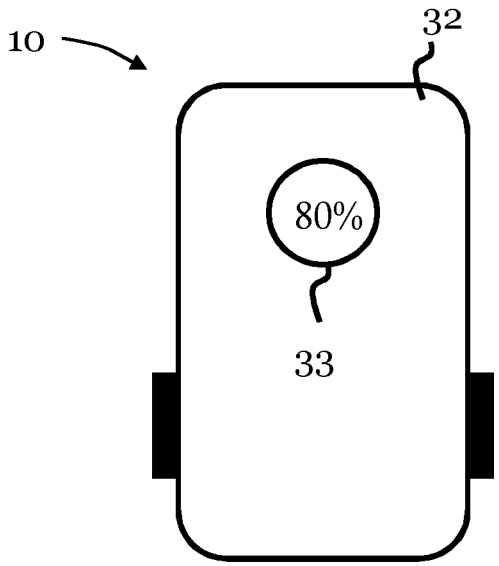


Figure 4

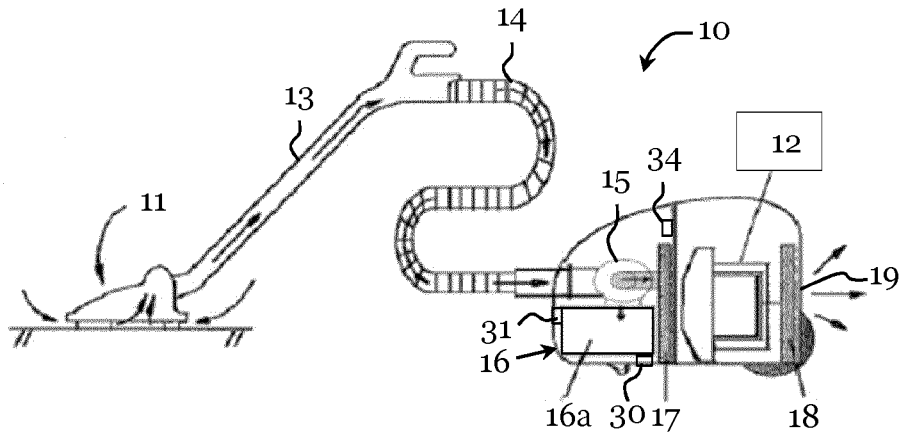


Figure 5

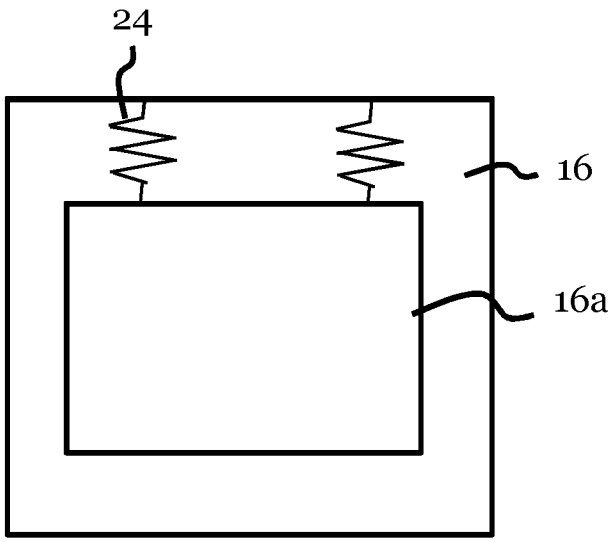


Figure 6

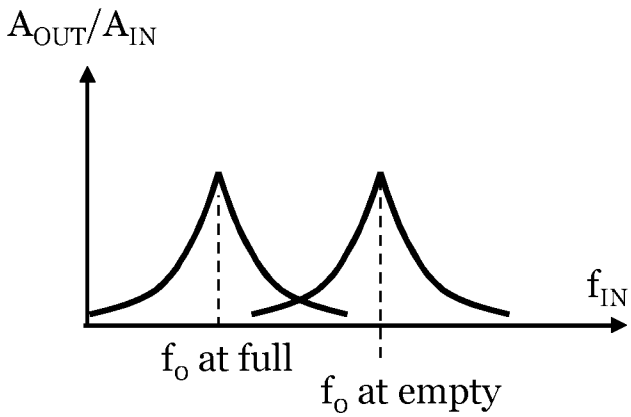


Figure 7

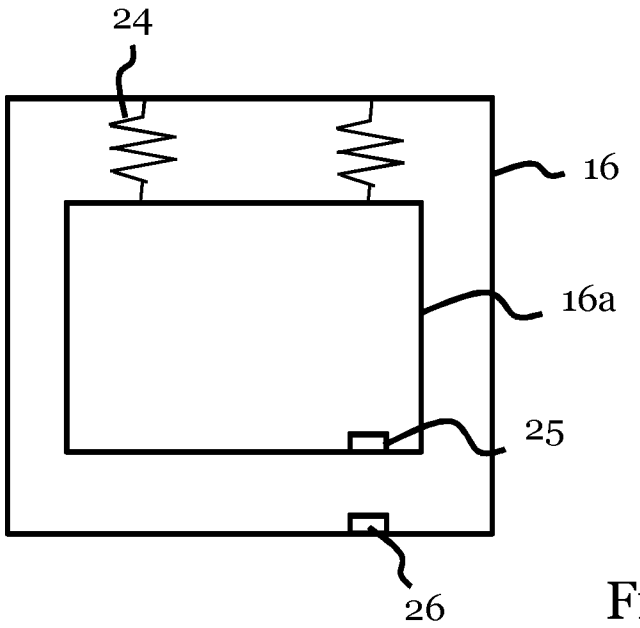


Figure 8

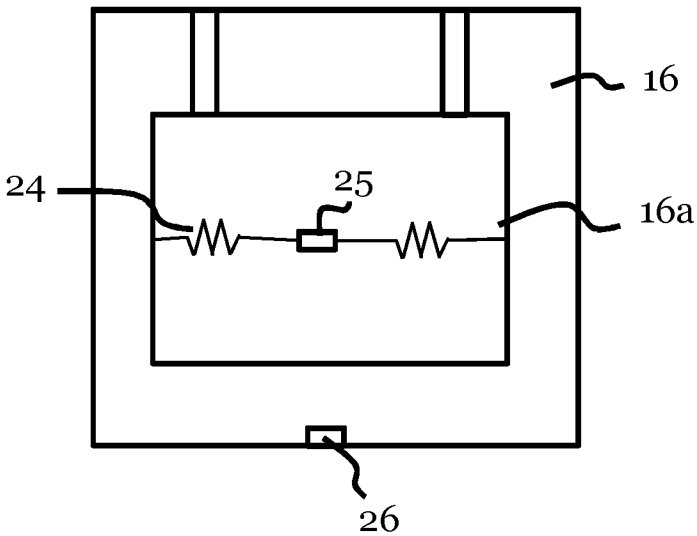


Figure 9

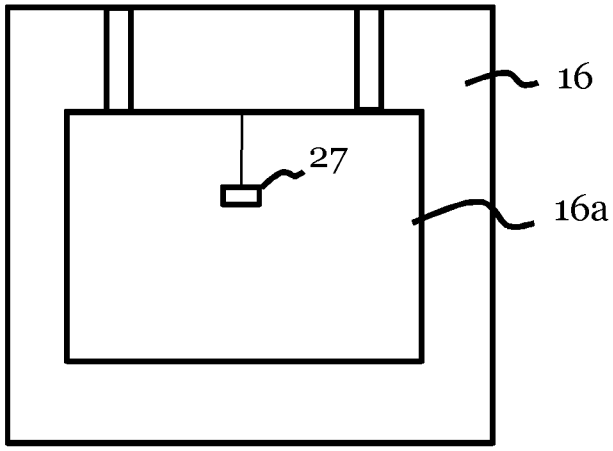


Figure 10

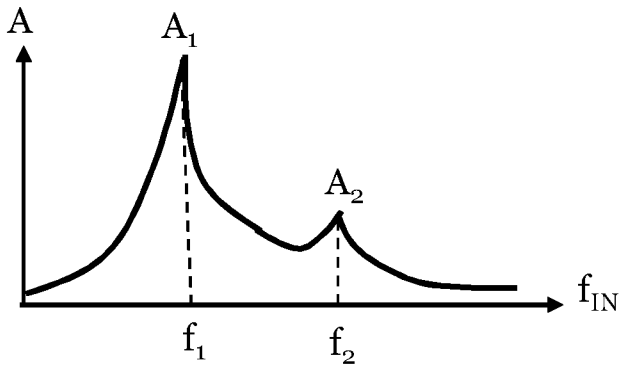


Figure 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2020/053444

A. CLASSIFICATION OF SUBJECT MATTER
INV. A47L9/28
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)
A47L

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	KR 2018 0046259 A (LS AUTOMOTIVE TECH CO LTD [KR]) 8 May 2018 (2018-05-08) paragraph [0022] - paragraph [0022]; figure 9 paragraph [0080] - paragraph [0080] paragraph [0113] - paragraph [0117] -----	1-5, 11-15,21 6-10, 16-20, 22,23
X A	EP 2 820 991 A1 (BRÖNDUM AS V [DK]) 7 January 2015 (2015-01-07) paragraph [0016] - paragraph [0020]; figure 1a -----	23 1-22

☐ 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
6 March 2020	16/03/2020

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Blumenberg, Claus

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2020/053444

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
KR 20180046259 A	08-05-2018	NONE	
EP 2820991 A1	07-01-2015	DK 177913 B1	15-12-2014
		EP 2820991 A1	07-01-2015
		EP 2820992 A1	07-01-2015