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(54) **SUCTION HOSE FOR USE WITH A SUCTION DEVICE**

(57) The invention refers to a suction hose (12) for use with a suction device (2), comprising a radio receiver (28) for receiving radio signals across a radio link (30). The suction hose (12) comprises a first end (14) connected to a suction opening (10) of the suction device (2) and an opposite second end (16) connected to an air outlet (18) of a hand-held electric or pneumatic power tool (20). A communication device (32) is located at or near the second end (16) of the suction hose (12), the communication device (32) comprising:

- a sensor element (34) for detecting a current operation status of the hand-held electric or pneumatic power tool (20) and for outputting a sensor signal (36) depending on the detected operating status of the power tool (20),
- a radio transmitter (38) for transmitting a radio signal

across the radio link (30), and

- a processing device (40) which is in operative connection with the sensor element (34) on the one hand and with the radio transmitter (38) on the other hand and which is adapted to cause the radio transmitter (38) to emit a radio signal depending on a sensor signal (36) received from the sensor element (34).

The communication device (32) is designed to realise only unidirectional communication across the radio link (30). Manually operated switching means are assigned to the communication device (32), in particular one or more buttons, switches, keys or dials, configured to be manually actuated by a user of the power tool (20) for controlling the suction device (2) via the unidirectional communication across the radio link (30).

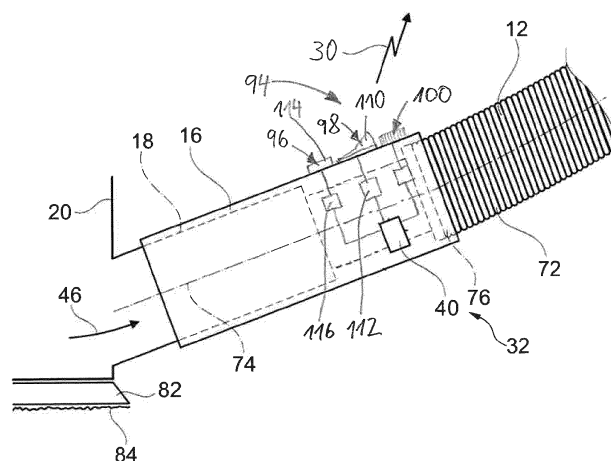


Fig. 4

Description

[0001] The present invention refers to a suction hose adapted for use with a suction device, in particular vacuum cleaner or dust extraction system, comprising a radio receiver for receiving radio signals. The suction hose comprises a first end adapted to be connected to a suction opening of the suction device and an opposite second end adapted to be connected to an air outlet of a hand-held electric or pneumatic power tool, and a communication device located at or near the second end of the suction hose. The communication device comprises:

- a sensor element for detecting a current operation status of the hand-held electric or pneumatic power tool and for outputting a sensor signal depending on the detected operating status of the power tool,
- a radio transmitter for transmitting a radio signal, and
- a processing device which is in operative connection with the sensor element on the one hand and with the radio transmitter on the other hand and which is adapted to cause the radio transmitter to emit a radio signal depending on a sensor signal received from the sensor element and optionally taking into account further parameters.

[0002] Such a suction hose and a suction device with which the suction hose can be used is known, for example, from EP 2 628 427 A1 and from US 2021/ 022 572 A1. The known suction devices each comprise:

- a collection container adapted to receive dust, dirt and small particles,
- a vacuum generating device for generating a low pressure lower than the ambient pressure in the collection container,
- a suction opening in the collection container,
- a suction hose connected at a first end to the suction opening and connectable at an opposite second end to an air outlet of a hand-held electric or pneumatic power tool,
- a filter element which is arranged in an air flow generated by the low pressure in the collection container between the collection container and the vacuum generating device and which is adapted to filter dust, dirt and small particles out of the air flow,
- a control device adapted to control the vacuum generating device in order to turn the vacuum generating device on or off depending on an operating status of the hand-held electric or pneumatic power tool to whose air outlet the second end of the suction hose is connected and optionally taking into account further parameters,
- a radio receiver for receiving radio signals, the radio receiver being in operative connection with the control device,
- a communication device located at or near the second end of the suction hose and comprising:

- a sensor element for detecting a current operation status of the hand-held electric or pneumatic power tool and for outputting a sensor signal depending on the operating status of the power tool,
- a radio transmitter for transmitting a radio signal, and
- a processing device which is in operative connection with the sensor element on the one hand and with the radio transmitter on the other hand and which is adapted to cause the radio transmitter to emit a radio signal depending on a sensor signal received from the sensor element and optionally taking into account further parameters.

[0003] The known suction device has a bidirectional radio link between the communication device of the suction hose assigned to the hand-held power tool and the suction device, in order to conduct a bidirectional communication between the power tool and the suction device during intended use (after start-up and initialization of the radio link). In this manner, it is possible to control the suction device depending on the operation status of the power tool and to control the power tool depending on the operation status of the suction device. When the power tool is turned on or off, the vacuum generating device of the suction device may be turned on or off, respectively. The operational speed of the vacuum generating device may be adapted to the operational speed of the power tool. In the opposite direction, the operational speed of the power tool may be adapted to the suction and/or filtering capabilities of the suction device. For example, if the filter element is partly blocked with dust, dirt and small particles or if the collection container has reached a certain filling level, the suction capabilities of the suction device are reduced and, consequently, the operational speed of the power tool is reduced in order to reduce the amount of dust, dirt and small particles conveyed to the suction device through the air flow.

[0004] Furthermore, in EP 2 628 427 A1 in order to manually control the vacuum cleaner, as user of the power tool has to refer to respective manually operated switching means located at the external housing of a remote vacuum cleaner. The switching means are provided for turning on or off the suction device of the vacuum cleaner and/or for increasing or reducing a rotational speed of a vacuum generating device of the suction device and/or for initiating, terminating or controlling a flushing of one or more filter elements of the suction device by a reverse air flow. This interrupts the workflow the user is currently in with the power tool polishing or sanding a working surface. It is also tedious and time-consuming for the user to have to move to the remote vacuum cleaner and to bend down to the manually operated switching means of the vacuum cleaner. Therefore, it is an object of the present invention to provide a suction device which on the one hand permits control of the vac-

uum generating device of the suction device by means of a particularly resource- and cost-efficient radio communication hardware and which on the other hand can be conveniently controlled manually by a user of the power tool.

[0005] This object is solved by a suction hose comprising the features of claim 1. In particular, it is suggested that the suction hose of the above-identified kind has a communication device which is designed to realise only unidirectional communication from the radio transmitter of the communication device to the radio receiver of the suction device. This refers in particular to the intended use of the radio link, that is when user data is transmitted from the communication device to the radio receiver of the suction device for controlling operation of the vacuum cleaner. Of course, during a start-up or initialisation phase of the radio link, it may well be possible that start-up and initialisation data is transmitted across the radio link in both directions, thereby permitting build-up and initialisation of the radio link. In particular, it is suggested that details and parameters of the radio link, e.g., unique identifiers of the participants, i.e., the radio transmitter and the radio receiver, frequency range or frequency band used for the radio link, format of signals and messages and protocol used for the radio signal transmission, etc., are agreed upon during a start-up procedure of the radio link where a communication in both directions is exceptionally possible.

[0006] Of course, one or more of the mentioned details or parameters of the radio link could also be preset prior to the intended use of the radio link and the suction device, respectively, which means they do not have to be exchanged or agreed upon in the course of a temporary communication in both directions during the start-up or initialisation phase. In particular, the hardware of the radio transmitter and the radio receiver, respectively, and the software for controlling the radio signal transmission across the radio link are embodied and designed such that during intended use of the radio link they realize only a unidirectional communication from the radio transmitter of the communication device to the radio receiver of the suction device.

[0007] Furthermore, according to the invention, the communication device is provided with manually operated switching means, in particular one or more buttons, switches, keys or dials, configured to be manually actuated by a user of the power tool for turning on or off the suction device and/or for increasing or reducing a rotational speed of a vacuum generating device of the suction device and/or for initiating, terminating or controlling a flushing of one or more filter elements of the suction device by a reverse air flow. Other functions of the suction device may also be initiated, terminated or controlled manually through the switching means. Respective control signals may be generated by the communication device in response to an actuation of the switching means by a user. The control signals are transmitted from the radio transmitter of the communication device to the radio

receiver of the suction device as radio signals via the unidirectional communication link and forwarded to the control device of the suction device. The control device causes a respective reaction (e.g., turning on or off a vacuum generating device and/or increasing or reducing a rotational speed of the vacuum generating device and/or initiating, terminating or controlling a flushing of one or more filter elements) of the suction device responsive to the received control signals and the manual actuation of the switching device, respectively. This way it is possible that a user of the power tool controls the suction device comfortably, as the communication device is located at or near the second end of the suction hose, which is attached to the air outlet of the power tool.

[0008] The communication device being located at or near the second end of the suction hose and therefore near the power tool operated by a user, provides for manually operated switching means for controlling the suction device close to the power tool and, therefore, also so close to the user operating the power tool that the user may actuate the switching means without having to interrupt operation of the power tool. Manual operation of the suction device by the user is highly simplified due to the fact that the switching means are readily available to and accessible by the use even during intended use of the power tool. Switching signals generated by the switching means are transmitted unidirectionally from the communication device to the suction device for realizing the respective control of the suction device depending on the actuation of the switching means. This permits a very convenient yet low-cost remote control of the suction device.

[0009] The manual switching means may comprise manually operable actuating elements which act on mechanically movable switching elements. A manual actuation of an actuating element by a user causes a movement of the switching element and a closing or opening of one or more electrical contacts. Alternatively, the switching means may also have electrically, inductively or capacitively operable actuating means which act on electrical switching elements (e.g., diodes, transistors or the like). Touching an electrically, inductively or capacitively actuatable actuating means with a user's finger causes the electrical switching element to switch.

[0010] The switching means could also comprise one or more mechanical, electrical, inductive or capacitive rotary controls, dials or the like, adapted for actuation by the user in order to set one or more parameters of the suction device, e.g., a speed of the vacuum generating device to a desired value. The parameters can be set continuously or in several discrete steps.

[0011] The switching means of the communication device could also comprise a push-button, and the suction device itself is also provided with a similar push-button. In particular, the push-button of the suction device is located on or at the housing of the suction device, in particular in or at a top part of the housing. In order to couple the communication device to the suction device, i.e., to

couple the radio transmitter of the communication device to the radio receiver of the suction device, the two push-buttons at the communication device and at the suction device are actuated (e.g., by pressing or simply touching) contemporarily or consecutively within a short period of time. This starts a coupling process of the two participants of the radio link and possibly also an establishment and/or an initialization of the radio link. Each participant may store the unique identification code of the respective other participant and possibly also other details or parameters of the radio link.

[0012] The actual unidirectional data transmission across the radio link during the intended use of the radio link may start automatically, once the sensor element of the communication device detects an operation of the power tool, to which the second end of the suction hose is connected. Alternatively, the unidirectional data transmission across the radio link during the intended use of the radio link may start manually, once one of the switching means intended for controlling one or more functionalities of the suction device, is actuated by the user of the power tool.

[0013] Preferably, the radio link corresponds to a Bluetooth standard, in particular to a Bluetooth Low Energy (BTLE) standard. It is further preferred that for the data transmission during the intended use of the radio link makes use of the Bluetooth advertising functionality. This functionality is usually used for mobile marketing to deliver content such as messages, information or advertisement to mobile devices such as cellular phones or tablet computers. Bluetooth advertising is a permission-based advertising scheme. The recipient needs to positively indicate that he wishes to receive advertising messages.

[0014] In the present case, the permission of the radio receiver of the suction device to receive advertising messages from the radio transmitter of the communication device may be preset or agreed upon during coupling, establishing and/or initialization of the radio link. The radio receiver of the suction device may be continuously or at discrete times (e.g., regularly) listening for advertising messages from the radio transmitter of the communication device.

[0015] The command for controlling the suction device can be contained in the useful content of the transmitted message(s). Alternatively, it is also conceivable that the command is specified or coded by a special format of the transmitted message(s).

[0016] The invention provides for an easy-to-realize unidirectional radio signal transmission. Nonetheless, the unidirectional radio link allows a control of the vacuum generating device of the suction device depending on the current operation status of the hand held electric or pneumatic power tool. Further, the invention allows a reliable and accurate determination of the operation status even of a pneumatic power tool. Furthermore, the invention can be combined even with existing power tools which have no radio communication functionality at all.

By connecting the second end of the suction hose to the power tool, its operation status can be easily and reliably determined by the sensor element of the communication device, even if the power tool itself works without electricity and has no means whatsoever to determine its current operation status and to communicate it to the suction device via the unidirectional connection.

[0017] The current operation status of the power tool is transmitted via the unidirectional communication across the radio link previously established between the radio transmitter assigned to the power tool and the radio receiver assigned to the suction device. The operation status of the power tool will be taken into account for controlling the operation of the vacuum generating device of the suction device. Optionally, further parameters may be taken into account for the control of the vacuum generating device. For example, further operation parameters of the hand-held electric or pneumatic power tool (e.g., time of continuous operation since last stop, accumulated time of operation since last replacement of polishing or sanding pad, temperature of the electronics of the power tool, state of charge of a battery of the power tool, amount of dust generated by the power tool per time unit) or of the suction device (e.g., accumulated time of operation since last replacement of filter element, pressure values on both sides of the filter element (seen in the direction of the air flow through the filter element) or respective differential pressure), environmental parameters and parameters of the workpiece to be worked by the hand-held electric or pneumatic power tool may be taken into account. The further operation parameters of the power tool are preferably also transmitted via the unidirectional communication across the radio link established between the radio transmitter assigned to the power tool and the radio receiver assigned to the suction device. The environmental parameters may be acquired by respective sensors making part of the suction device and/or the power tool. The parameters of the workpiece may be entered manually by a user of the power tool or of the suction device, for example, by means of a user interface of the power tool or of the suction device, or by means of a user's mobile device connected to the power tool or the suction device, for instance by means of a radio link.

[0018] The collection container may be formed by part of an external housing of the suction device. Preferably, the collection container is made of a plastic material. The collection container may be provided with wheels at its bottom side in order to allow manoeuvring of the suction device to its intended location of use. The collection container may comprise an opening for emptying the container and removing dust, dirt and small particles gathered therein. The opening is hermetically closed by means of a removable lid or cover or the like. A suction device with an opening in the collection container is known, for instance, from EP 1 262 135 A2, the content of which is incorporated herein by reference. The collection container may be equipped with a dust bag made of

textile or paper, if desired. The dust bag may be removed through the opening in the collection container.

[0019] If a low pressure or vacuum is generated inside the collection container by means of the vacuum generating device, the differential pressure between the low pressure in the collection container and the environmental pressure creates an air flow, which is sucked into the collection container through the container's suction opening. The air flow may carry dust and other small particles from the working area of the power tool. The dust laden air flow is further sucked through the filter element towards the vacuum generating device. The filter element separates dust and particles from the dust laden air flow so that a clean air flow is obtained. The vacuum generating device discards the filtered clean air flow into the environment through respective outlet openings in the external housing of the suction device in which the dust generating device is housed.

[0020] The suction device may have one or more filter elements. If more than one filter element is provided in the suction device, the filter elements are preferably arranged in parallel in respect to the air flow passing there through. Thus, the air flow can pass through all filter elements at the same time or only through one or more selected filter elements. Furthermore, one or more selected filter elements may be penetrated by a dust laden air flow in a first direction during intended use of the suction device while at the same time one or more other selected filter elements may be penetrated by a clean air flow in the opposite direction during a temporary cleaning step of the one or more other selected filter elements. To this end, one or more selected filter elements can be cleaned while the intended use of the suction device can be maintained. The air flow through the one or more filter elements can be controlled by means of pneumatic solenoid valves and/or respective air flaps, which are controlled, for instance, by means of the control device of the suction device through electric motors, solenoids or the like. Such a cleaning of filter elements by reverse flushing one or more selected filter elements with a clean air flow in a direction opposite to the direction of the dust laden air flow, may be realized, for instance, according to EP 1 997 415 A1, which is incorporated herein by reference.

[0021] The vacuum generating device may comprise a motor which drives a turbine for generating an air flow from the collection container into the environment and passing through the filter element, thereby creating the low pressure in the collection container. The motor of the vacuum generating device is preferably an electric motor, in particular of the brushless type. However, it could also be a pneumatic motor actuated by compressed air. In that case, the electric energy necessary for operating the control device and the radio receiver of the suction device could be provided by a battery or an electric energy generating device (e.g., a pneumatic generator located in the air stream of the compressed air or a dynamo actuated through the pneumatic motor) making part of the

suction device.

[0022] The suction hose has an elongated intermediate section which is preferably flexible and made of a plastic material or metal. The intermediate section is preferably corrugated in order to enhance its flexibility when bending it about a bending axis extending essentially perpendicular to the longitudinal axis of the hose and for improving its stability and resilience against external forces acting on the intermediate section in a direction essentially perpendicular to the longitudinal axis of the hose.

[0023] The first and second ends of the suction hose have a rigid structure and are attached to the elongated preferably flexible intermediate section. In particular, it is suggested that at least one of the rigid end pieces of the hose is attached to the elongated intermediate section in a manner freely rotatable about the longitudinal axis of the hose in respect to the intermediate section. The first and second end pieces may be made of a plastic material or metal. The first end of the suction hose is attached to the container's suction opening and the second end is attached to the air outlet of a hand held power tool. By connecting the air outlet of the power tool to the container's suction opening through the suction hose, the low pressure in the collection container generates an air flow from the air outlet through the suction hose into the collection container. The air flow at the air outlet creates a low pressure at the working area of the power tool, which provokes that dirt, dust and small particles are drawn away from the working area by the air flow and sucked up by the suction device and filtered out of the dust laden air flow by the filter element of the suction device.

[0024] Attachment of the first and second end pieces of the suction hose to the suction opening of the collection container of the suction device and to the air outlet of the power tool, respectively, can be realized by means of a plug-in connection. The first and second end pieces can be held in place in respect to the suction opening and/or the air outlet, respectively, by means of friction, a snap-in connection, a bayonet connection, magnetic force or the like. A suction hose with distal end pieces which are magnetically secured to a suction opening of a collection container of a suction device and to an air outlet of a power tool, respectively, is described, for example, in European application EP 3 922 157 A1, which is incorporated herein by reference in its entirety.

[0025] In general, the power tool could be any electric or pneumatic power tool which during its intended use creates a certain amount of dust, dirt or other small particles. The power tool may be equipped with a self-generated dust extraction functionality which creates an internal air flow which conveys dust, dirt and small particles from the working area of the power tool towards the air outlet. Alternatively, the power tool may not have a self-generated dust extraction functionality, in which case the dust, dirt and small particles from the working area of the power tool are sucked towards the air outlet by means

of the air flow created by the suction device.

[0026] The power tool is preferably a sanding tool (or sander) or a grinding tool (or grinder). A sanding tool may have a backing plate, to which a sanding medium (e.g., an abrasive paper or fabric, an abrasive pad or the like) may be releasably attached, e.g., by means of a Velcro®. Depending on the type of power tool, the backing plate performs a purely rotational, a random orbital, an eccentric or a roto-orbital (gear-driven) working movement. However, an abrasive pad could also be directly attached to the sanding tool without the intermediate element in the form of the backing plate. A grinding tool has a carrier element to which a grinding wheel made in its entirety of a rigid material is releasably attached. The carrier element and the grinding wheel attached thereto perform a purely rotational working movement. The grinding wheel may be used for cutting stone and metal.

[0027] Alternatively, the power tool could also be a drill or a hammer drill comprising a drill chuck into which a drill bit is inserted and fastened. The drill chuck and the drill bit perform a purely rotational working movement. The drill or hammer drill may be provided with a shroud which covers the working area, at least part of the drill bit and possibly also the drill chuck in part or in its entirety. The shroud may be attached to a front part of a housing of the drill or hammer drill. The shroud may be provided with an air outlet to which the second end of the suction hose is attached.

[0028] According to a preferred embodiment, it is suggested that the processing device of the communication device is adapted to cause the radio transmitter to emit a radio signal when the power tool changes from a turned-off to a turned-on operating status, and in that the control device is adapted to switch on the vacuum generating device of the suction device when the radio receiver receives the radio signal and optionally taking into account further parameters. Additionally or alternatively, it is suggested that the processing device of the communication device is adapted to cause the radio transmitter to emit a radio signal when the power tool changes from a turned-on to a turned-off operating status, and in that the control device is adapted to switch off the vacuum generating device of the suction device when the radio receiver receives the radio signal and optionally taking into account further parameters.

[0029] Of course, it would be possible to switch the vacuum generating device on without delay after the sensor element has detected an operation of the power tool and a respective radio signal has been transmitted by the radio transmitter and received by the radio receiver and/or to switch the vacuum generating device off without delay after the sensor element has detected an end of operation of the power tool and a respective radio signal has been transmitted by the radio transmitter and received by the radio receiver.

[0030] Preferably, at least one of switching the vacuum generating device on or off is realized only after a certain time delay in respect to the detection of the start or end

of operation of the power tool by means of the sensor element and in respect to the receipt of the respective radio signal by means of the radio receiver of the suction device. The time delay may be in the region of one to a few seconds. A time delay before switching on the vacuum generating device saves energy in that the power tool first creates dust, dirt or small particles which then can be efficiently sucked up by the suction device immediately upon its activation. A time delay before switching off the vacuum generating device provides for an efficient suction of dust, dirt and other small particles which have been generated during the intended use of the power tool. After the end of the intended use and operation of the power tool, there are still dust, dirt and small particles in the working area and/or in the air outlet of the power tool and/or in the suction hose, which are consequently removed by the suction device still in operation during the time delay before being switched off. The idea is to keep the vacuum generating device switched on so long until all the remaining dust, dirt and small particles have been sucked into the suction device and collected in the collection container.

[0031] To this end it is suggested that the processing device of the communication device is adapted to take into account as a further parameter, when causing the radio transmitter to transmit a radio signal, a time delay between the reception of the sensor signal from the sensor element and the transmission of the radio signal by the radio transmitter. Additionally or alternatively, it is suggested that the control device of the suction device is adapted to take into account as a further parameter, when switching on or switching off the vacuum generating device, a time delay between the reception of the radio signal by the radio receiver and the switching on or switching off of the vacuum generating device.

[0032] The radio link may comprise any type or standard of known short-range wireless radio links, including but not limited to Bluetooth, WLAN (WiFi), NFC and any type of proprietary type of radio link.

[0033] Further, it is possible that communication parameters and/or a unique identifier of the radio transmitter is preset in the radio receiver at the factory and that communication parameters and/or a unique identifier of the radio receiver are preset in the radio transmitter at the factory. Alternatively, the communication parameters and unique identifiers may be set by a user through a user interface of the suction device and/or of the communication device. Different unique identifiers and possibly other communication parameters of the radio link may be stored in the communication device assigned to the suction hose at the factory and then a specific identifier and specific parameters may be selected by a user according to the requirements of the radio receiver of the suction device, in order to realize the unidirectional data communication between the communication device and the receiver across the radio link. Alternatively, different unique identifiers and possibly other radio link parameters may be stored in the radio receiver or a storage de-

vice assigned thereto at the factory and then a specific identifier and specific parameters may be selected by a user according to the requirements of the communication device or its radio transmitter, respectively, in order to realize the unidirectional data communication between the communication device of the suction hose and the radio receiver of the suction device across the radio link. Of course, instead of storing the unique identifiers and/or communication parameters in the communication device, one or more of them could be established, exchanged or agreed upon via a temporary communication in both directions during establishment, start-up and/or initialisation of the radio link, before the intended use of the radio link.

[0034] Furthermore, the communication parameters and unique identifiers may be set by a user through a mobile end user device which is connected to the suction device and/or to the communication device through a further radio link.

[0035] A radio link between the radio transmitter and the radio receiver, by means of which the radio signal is transmitted from the communication device to the suction device, may be manually configured by a user of the suction device and/or the power tool after shipment and prior to use of the suction device and the power tool, respectively. Preferably, the radio link between the radio transmitter and the radio receiver is manually configured by the user of the suction device and/or the power tool by means of hardware and/or software. A hardware configuration may comprise the setting of respective dip-switches in the radio receiver and/or radio transmitter or the setting of the communication parameters and/or unique identifiers through a user interface making part of the suction device and/or the communication device. A software configuration may comprise a computer program, e.g., an application or app, running on an end user device, e.g., a Personal Computer, a laptop or a smartphone, and in which computer program the appropriate settings can be made. The computer program may then transmit the settings to the radio receiver and/or radio transmitter in order to configure the radio link. Transmission of the settings may be realized by means of a cable or wireless.

[0036] It is further suggested that the communication device comprises an independent, local power supply unit. The power supply unit may comprise a rechargeable and/or replaceable battery. The electric energy stored therein is used for operating the sensor element, the processing device and the radio transmitter. It would also be possible to provide the communication device with an energy transformation device, which can transform the vibrations of the second end of the suction hose caused by the vibrating power tool during its intended use into electric energy which is supplied to the battery for recharging (energy harvesting from mechanical movements) or directly to the electric components (e.g., sensor element, the radio transmitter and the processing device) of the communication device. Alternatively, the energy

transformation device may comprise a pneumatic generator located in the air stream through the second end of the suction hose which will generate electric energy for the electric components of the communication device, once the power tool with a self-generated dust extraction functionality is activated.

[0037] Due to the fact that the communication device transmits a radio signal only occasionally when the power tool is turned on and/or off, the power supply unit would have an almost infinite lifetime without running out of electric energy. To this end, the energy transformation device may comprise piezoelectric materials, may be in the form of an electrodynamic or inductive generator or may be in the form of an electrostatic generator.

[0038] According to a further preferred embodiment, it is suggested that the suction device has a visual and/or acoustic signalling device which communicates a status of the power supply unit of the communication device visually and/or acoustically to a user of the suction device and/or the power tool. The signalling device may be located at and make part of the communication device assigned to the power tool. Alternatively, it may be located at that part of the suction device where the low pressure or vacuum is generated. For example, the visual and/or acoustic signalling device could be located in or at an external housing of the suction device well visible and/or audible by a user of the suction device and/or the power tool. In that case, the communication device or the radio transmitter, respectively, would have to communicate the current status of the power supply unit to the radio receiver of the suction device for output by the signalling device. This could preferably be effected by transmitting a respective status message across the radio link established between the radio transmitter and the radio receiver. The status of the power supply unit preferably corresponds to a charge level of the power supply unit. In a simple embodiment the status could simply comprise the information whether the charge level of the power supply unit is sufficient in order to assure proper functioning and full operability of the electric components of the communication device (green light and/or no acoustic signal) or not (red light and/or flashing light and/or acoustic signal). Alternatively, different charge levels of a battery of the power supply unit could provoke different visual and/or acoustic output signals by the signalling device.

[0039] The communication device may be realised in different embodiments. According to a preferred embodiment, the communication device is a self-contained unit which is detachably attached to the second end of the suction hose, similar to a wrist watch which is attached to the wrist of a user. In particular, the communication device may have a housing, e.g., made of a plastic or rubber material, in which all components of the communication device are located. The housing of the communication device may be completely sealed off, in order to provide for a moisture-proof and dust-proof encapsulation of the components. The communication device may be provided with straps which are looped around the sec-

ond end of the suction hose and then fastened together, e.g., by means of a buckle, a Velcro® or the like. Alternatively, some kind of fastening structure, e.g., a Velcro® or a snap-in structure, may be provided at the second end of the suction hose, and the communication device is releasably attached to the fastening structure. In this embodiment, the communication device may be replaced in its entirety, if desired.

[0040] Alternatively, it is suggested that the communication device is integrated in the second end of the suction hose, preferably by means of a moulding process during manufacturing of the second end piece of the suction hose and/or the entire suction hose. According to this embodiment, the communication device is an integral part of the second end piece of the suction hose. In order to replace the communication device, the entire second end piece and/or the entire suction hose would have to be replaced. This embodiment may have considerable advantages in terms of a cost-efficient production and integration of the communication device in the suction hose, because the second end of the suction hose may also serve as a housing for the communication device and its components. Even if integrated into the second end of the suction hose, the suction hose or the second end piece, respectively, may be provided with a closable maintenance opening which permits access to the components of the communication device for repair or replacement, e.g., for replacement of a battery of the power supply unit if exhausted, and/or for replacement of the radio transmitter in order to change the frequency band on which the radio signals are transmitted to the radio receiver, and/or to switch a dip-switch or the like to set the radio transmitter to another frequency for the radio communication.

[0041] The sensor element for detecting the operation status of the power tool may be embodied in many different ways. According to preferred embodiments, the sensor element is designed as an acceleration sensor for detecting vibrations of the suction hose during operation of the hand-held electric or pneumatic power tool or as a flow sensor for detecting an air flow in the second end of the suction hose, which is attached to the air outlet of the power tool, during operation of the power tool. An operation of the power tool will inevitably lead to vibrations, which may be detected by the acceleration sensor. This is in particular the case for oscillating power tools, e.g., a random-orbital sander, a gear-driven sander or the like. The acceleration sensor may be in the form of a piezoelectric accelerometer. If the power tool is provided with a self-generated dust extraction functionality, operation of the power tool will inevitably lead to an air flow of possibly dust-laden air from the working area to the air outlet of the power tool. This air flow may be detected by the flow sensor. The flow sensor preferably has a measuring probe positioned in the air flow. Alternatively, the flow sensor may detect the air flow optically, by means of ultra-sonic waves or other types of electromagnetic waves.

[0042] Alternatively or additionally, the sensor element could also comprise an optical or other type of sensor for detecting the amount of dust and other small particles of the dust laden air passing through the second end of the suction hose. Preferably, the sensor determines the amount of dust or other small particles per time unit. A status message containing or indicative of the determined amount of dust or small particles, preferably per time unit, could be transmitted by the radio transmitter across the radio link to the radio receiver of the suction device. The rotational speed of the vacuum generating device could be increased or decreased according to the determined amount of dust or small particles.

[0043] Finally, it is suggested that the suction device has a main switch for manually switching the suction device between an operational status (I) and an inactive status (0) and that the control device is designed to turn on the vacuum generating device depending on an operating status of the hand-held electric or pneumatic power tool to whose air outlet the second end of the suction hose is connected, only when the suction device is in an operational status (I). With other words, by switching the suction device into the operational status (I), it may be brought into a kind of standby-mode in which the vacuum generating device is not yet in operation. Only if additionally, the sensor element detects an operation of the power tool, to which the suction hose is attached, will the vacuum generating device be turned on. As previously mentioned, turning on the vacuum generating device can be accomplished almost contemporarily with the activation of the power tool or with a time delay. If the sensor element detects the end of an operation of the power tool, the vacuum generating device will be turned off. Again, this can be accomplished almost contemporarily with the deactivation of the power tool or with a time delay.

[0044] Of course, apart from turning on and off of the suction device automatically by means of the communication device, it is also possible to turn on and off the suction device manually by means of actuation of the switching means.

[0045] Further features and advantages of the present invention will be described hereinafter with reference to a preferred embodiment shown in the figures. It is emphasized that each of the features shown in the figures may be an important aspect of the invention. Furthermore, various features shown in the figures may be combined with each other in any possible manner, even if not explicitly shown in the figures and/or mentioned in the description. The figures show:

Fig. 1 a preferred embodiment of the suction device according to the present invention attached to a hand-held power tool;

Fig. 2 a first embodiment of the second end of the suction hose of the suction device according to Fig. 1 attached to an air outlet of a hand-held power tool; and

Fig. 3 a second embodiment of the second end of the suction hose of the suction device according to Fig. 1 attached to an air outlet of a hand-held power tool.

[0046] Fig. 1 shows a suction device 2 according to the present invention in the form of a mobile vacuum cleaner or a mobile dust extraction system. The suction device 2 is adapted for filtering dust, dirt and small particles from a flow 24 of dust-laden air and for collecting and temporarily storing the dust, dirt and small particles 6 in a collection container 4. In particular, the suction device 2 comprises:

- the collection container 4 adapted to receive dust, dirt and small particles 6,
- a vacuum generating device 8 for generating a low pressure p_v in the collection container 4, which is lower than an ambient pressure p_0 ,
- a suction opening 10 in the collection container 4,
- a suction hose 12 connected at a first end 14 to the suction opening 10 and connected at an opposite second end 16 to an air outlet 18 of a hand-held electric or pneumatic power tool 20,
- a filter element 22 which is arranged in the air flow 24 generated by the vacuum generating device 8 and between the collection container 4 and the vacuum generating device 8 and which is adapted to filter dust, dirt and small particles 6 out of the air flow 24,
- a control device 26 adapted to control the vacuum generating device 8 in order to turn the vacuum generating device 8 on or off depending on an operating status of the hand-held electric or pneumatic power tool 20 to whose air outlet 18 the second end 16 of the suction hose 12 is connected,
- a radio receiver 28 for receiving radio signals across a radio link 30, the radio receiver 28 being in operative connection with the control device 26,
- a communication device 32 located at or near the second end 16 of the suction hose 12 and comprising:
 - a sensor element 34 for detecting a current operation status of the hand-held electric or pneumatic power tool 20 and for outputting a sensor signal 36 depending on the operating status of the power tool 20,
 - a radio transmitter 38 for transmitting a radio signal across the radio link 30, and
 - a processing device 40 which is in operative connection with the sensor element 34 on the one hand and with the radio transmitter 38 on the other hand and which is adapted to cause the radio transmitter 38 to emit a radio signal 30 depending on or indicative of a sensor signal 36 received from the sensor element 34.

[0047] In general, the power tool 20 could be any electric or pneumatic power tool which during its intended use creates a certain amount of dust, dirt or other small particles. The power tool 20 has an electric or pneumatic motor 80 for operating its working element 82. In the embodiment shown in Fig. 1, the power tool 20 is a sanding tool and the working element 82 is a backing plate. A sanding medium 84 (e.g., an abrasive paper or fabric, an abrasive pad or the like) may be releasably attached to a bottom surface of the backing plate 82, for instance by means of a Velcro®-connection. Depending on the type of sanding tool, the backing plate 82 performs a purely rotational, a random orbital, an eccentric or a roto orbital (gear-driven) working movement.

[0048] The power tool 20 may be equipped with a self-generated dust extraction functionality realized by means of a fan 86 which is preferably driven by the motor 80. The fan 86 creates an internal air flow 46 which conveys dust, dirt and small particles from the working area 78 of the sanding tool 20 towards the air outlet 18. Alternatively, the power tool 20 may not have a self-generated dust extraction functionality, in which case the dust, dirt and small particles from the working area 78 are sucked towards the air outlet 18 by means of the air flow 24, 46 created by the suction device 2.

[0049] It is suggested that the radio transmitter 38 of the communication device 32 making part of the suction device 2 and associated to the hand held power tool 20 on the one hand and the radio receiver 28 of the suction device 2 on the other hand are designed to realise an only unidirectional communication from the radio transmitter 28 of the communication device 32 to the radio receiver 28. This refers in particular to the intended use of the communication across the radio link 30, during which the suction device 2 and/or its operation is controlled. It is possible that all details of the radio link 30, e.g., unique identifiers of the radio transmitter 38 and the radio receiver 28, a frequency range or frequency band used for the radio link 30, a format of the radio signals transmitted across the radio link 30 and/or of respective messages, and a protocol used for transmission of the radio signals across the radio link 30, are preset prior to the intended use of the radio link 30 and the suction device 2, respectively. Alternatively, these identifiers and/or parameters may also be established, exchanged and/or agreed upon among the participants of the radio link 30 during a start-up procedure having a temporarily communication among the participants in both directions. Thus, as soon as the radio transmitter 38 and the radio receiver 28 are supplied with electric energy and have completed their start-up procedure they are ready for intended use of the radio link 30 and the respective radio signal transmittal or reception, respectively, for controlling operation of the suction device 2 and/or its vacuum generation device 8.

[0050] The hardware of the radio transmitter 38 and radio receiver 28, respectively, and the software for controlling the radio signal transmission across the radio link

30 during its intended use are embodied and designed such that a unidirectional communication is realized across the radio link 30 at least during the intended use of the radio link 30.

[0051] Preferably, the radio link 30 or the messages transmitted across the radio link 30, respectively, correspond to a Bluetooth standard, in particular to a Bluetooth low energy standard. Further, it is preferred to use a Bluetooth advertising functionality for transmitting the messages for the control of the suction device 2 or its functionality, respectively, during the intended use of the radio link 30. The messages are transmitted unidirectionally from the radio transmitter 38 of the communication device 20 to the radio receiver 28 of the suction device 2.

[0052] By connecting the second end 16 of the suction hose 12 to the power tool 20, its operation status can be easily and reliably determined by the sensor element 34 of the communication device 32, even if the power tool 20 itself works without electricity and/or has no means whatsoever to determine its current operation status and transfer the determined operation status to a radio receiver 28 of a suction device 2.

[0053] The current operation status of the power tool 2 is transmitted via the unidirectional communication across the radio link 30 previously established between the radio transmitter 38 assigned to the power tool 20 and the radio receiver 28 of the suction device 2. The operation status of the power tool 20 will be taken into account for controlling the operation of the vacuum generating device 8 of the suction device 2. Optionally, further parameters may be taken into account for the control of the vacuum generating device 8. For example, further operation parameters of the hand-held electric or pneumatic power tool 20 (e.g., time of continuous operation since last stop; accumulated time of operation since last replacement of polishing or sanding pad; temperature of the electronics of the power tool 20; state of charge of a battery of the power tool 20, amount of dust generated by the power tool 20 per time unit during its current operation) or of the suction device 2 (e.g., accumulated time of operation since last replacement of filter element 22, pressure values p_v , p_{in} on both sides of the filter element 22 (seen in the direction of the air flow 24 through the filter element 22) or a respective differential pressure $p_{in} - p_v$), environmental parameters and parameters of the workpiece to be worked by the hand-held electric or pneumatic power tool 20.

[0054] The further operation parameters of the power tool 20 are preferably also transmitted via the unidirectional communication across the radio link 30 established between the radio transmitter 38 assigned to the power tool 20 and the radio receiver 28 of the suction device 2. The environmental parameters may be acquired by respective sensors making part of the suction device 2 and/or the power tool 20. The parameters of the workpiece may be entered manually by a user of the power tool 20 or of the suction device 2, for example, by means of a user interface 50 of the power tool 20 or of the suction

device 2. The user interface 50 may comprise a touch-screen of a GUI and/or buttons or keys and/or a computer mouse or the like. Alternatively, the parameters of the workpiece may be entered manually by a user by means of a user's mobile end user device 52 connected to the power tool 20 or the suction device 2, for instance by means of a further radio link 54. The end user device 52 may be a Personal Computer, a laptop, a smartphone or the like.

[0055] Further, Figs. 4 and 5 shows an embodiment, where in accordance with the invention manually operated switching means 94 are assigned to the communication device 32. The switching means 94 comprise, for instance, one or more buttons 96, switches 98, keys or dials 100, configured to be manually actuated by a user of the power tool 20. It would also be conceivable to realize the switching means 94 by means of a GUI 106 of a touchscreen (see Fig. 5). Actuation of the switching means 94 serves for controlling the suction device 2, in particular for turning on or off the suction device 2 or its vacuum generation device 8, respectively, and/or for increasing or reducing a rotational speed of a motor 68 of the suction device 2 or its vacuum generation device 8, respectively, and/or for initiating, terminating or controlling a flushing of one or more filter elements 22 of the suction device 2 by a reverse air flow, via the unidirectional communication across the radio link 30.

[0056] Of course, additionally to what is shown in Figs. 4 and 5, the communication device 32 of Figs. 4 and 5 may also comprise one or more of the components 34, 38, 40, 42 and 50 shown in Fig. 2.

[0057] According to Fig. 4, the communication device 32 forms an integral part of the second end 16 of the suction hose 12. Alternatively, the communication device 32 of Figs. 4 and 5 could also be embodied as a self-contained unit separate from the second end 16 of the suction hose 12 and attached to the second end 16 by means of straps 90 or some other kind of fastening structure, similar to what is shown in Fig. 3.

[0058] According to the embodiment shown in Fig. 4, the manually operated switching means 94 form part of the communication device 32.

[0059] The switching means 94 may be adapted to create switching signals upon manual operation of the switching means 94 and to forward them to the processing device 40 of the communication device 32. The processing device 40 may be adapted to create radio signals indicative of the received switching signals. The radio transmitter 38 of the communication device 32 may be adapted to realize a transmission of the radio signals to the radio receiver 28 of the suction device 2 via the unidirectional communication across the radio link 30.

[0060] According to an alternative embodiment shown in Fig. 5, the manually operated switching means 94 form part of a remote control 102 physically separable from the communication device 32, the remote control 102 being in a data transmission connection 104 with the communication device 32. The data transmission con-

nection 104 may be realized by means of a cable or, as shown in Fig. 5, by means of a wireless connection, e.g., by means of a radio, infrared or ultrasonic connection. The remote control 102 may be realized as a smart phone, which may have a microprocessor on which a computer program (so-called application or app) is executed in order to enable control of the suction device 2 by means of the remote control 102.

[0061] The switching means 94 may be adapted to create switching signals upon manual operation of the switching means 94. The remote control 102 may be adapted to transmit the switching signals to the communication device 32 via the data transmission connection 104. The communication device 32 may have a receiver 108 for receiving the switching signals. The processing device 40 of the communication device 32 may be adapted to receive the switching signals and to create radio signals indicative of the received switching signals. The radio transmitter 38 of the communication device 32 is adapted to realize a transmission of the radio signals to the radio receiver 28 of the suction device 2 via the unidirectional communication across the radio link 30.

[0062] The manual switching means 94, 98 may comprise manually operable actuating elements 110 which act on mechanically movable switching elements 112. A manual actuation of an actuating element 110 by a user causes a movement of the switching element 112 and a closing or opening of one or more electrical contacts. Alternatively, the switching means 94, 96 may also have electrically, inductively or capacitively operable actuating means 114 which act on an electrical switching element 116 (e.g., diode, transistor or the like). Touching an electrically, inductively or capacitively actuatable actuating means 114 with a user's finger causes the electrical switching element 116 to switch.

[0063] The switching means 94, 100 could also comprise one or more mechanical, electrical, inductive or capacitive rotary controls, dials or the like, adapted for actuation by the user in order to set one or more parameters of the suction device 2. The rotary control, dial 100 or the like acts on a potentiometer switching element 118. Rotating or otherwise actuating the rotary control, dial 100 or the like will change electric properties, e.g., a resistance, of the switching element 118. By means of a rotary control, dial 100 or the like a speed of the vacuum generating device 8 may be set to a desired value. The operation parameters of the suction device 2 can be set continuously or in several discrete steps.

[0064] The collection container 4 may be formed by part 56 of an external housing of the suction device 2. Preferably, the collection container 4 is made of a plastic material. The collection container 4 may be provided with external wheels 58 in order to allow manoeuvring of the suction device 2 to its intended location of use.

[0065] If a low pressure p_v or vacuum is generated inside the collection container 4 by means of the vacuum generating device 8, the differential pressure between the low pressure p_v and the environmental pressure p_0

creates an air flow 24, which is sucked into the collection container 4 through the container's suction opening 10. The air flow 24 may carry dust and other small particles from the working area of the power tool 20. The dust laden air flow 24 is further sucked through the filter element 22 towards the vacuum generating device 8. The filter element 22 separates dust and particles 6 from the dust laden air flow 24 so that a clean air flow 60 is obtained. The vacuum generating device 8 discards the filtered clean air flow 60 into the environment through respective outlet openings 62 in another part 64 of the external housing of the suction device 2 in which the dust generating device 8 is housed. The bottom part 56 and the top part 64 of the external housing of the suction device 2 may be separated from each other along a plane 66 extending through the filter element 22. Preferably, the filter element 22 is attached to the top part 64 of the external housing.

[0066] Although only one filter element 22 is shown in Fig. 1, the suction device 2 may have more than one filter element 22. The one or more filter element 22 can be subject to a temporary cleaning step by reverse flushing one or more selected filter elements 22 with a clean air flow 60 in a direction opposite to the direction of the dust laden air flow 24. During the cleaning step the intended use of the suction device 2 can be maintained by operating those filter elements 22 currently not subject to the cleaning step in a normal manner (with the dust-laden air flow 24 penetrating them).

[0067] The vacuum generating device 8 may comprise a motor 68 which drives a turbine 70 for generating an air flow 24, 60 from the collection container 4 into the environment and passing through the filter element 22, thereby creating the low pressure p_v in the collection container 4. The motor 68 of the vacuum generating device 8 is preferably an electric motor, in particular of the brushless type. However, it could also be a pneumatic motor actuated by compressed air.

[0068] The suction hose 12 has an elongated intermediate section 72 which is preferably flexible and made of a plastic material or metal. The suction hose 12 extends along a longitudinal axis 74. The intermediate section 72 is preferably corrugated in order to enhance its flexibility when bending it about a bending axis extending essentially perpendicular to the longitudinal axis 74 of the hose 12 and for improving its stability and resilience against external forces acting on the intermediate section 72 in a direction essentially perpendicular to the longitudinal axis 74 of the hose 12.

[0069] The first and second ends 14, 16 of the suction hose 12 have a rigid structure and are attached to the elongated intermediate section 72. In particular, at least one of the rigid end pieces 14, 16 of the hose 12 is attached to the elongated intermediate section 72 in a manner freely rotatable about the longitudinal axis 74 of the hose 12 in respect to the intermediate section 72. A freely rotatable connection is indicated with reference sign 76 in Figs. 2 and 3. The first and second end pieces 14, 16

may be made of a plastic material or metal. The first end 14 of the suction hose 12 is attached to the container's suction opening 10, and the second end 16 is attached to the air outlet 18 of the hand-held power tool 20. By connecting the air outlet 18 of the power tool 20 to the container's suction opening 10 through the suction hose 12, the low pressure p_v in the collection container 4 generates the air flow 24 from the air outlet 18 through the suction hose 12 into the collection container 4. The air flow 24 at the air outlet 18 creates a low-pressure p_w at the working area 78 of the power tool 20, which provokes that dirt, dust and small particles are drawn away from the working area 78 by the air flow 46 and sucked up by the suction device 2 and filtered out of the dust laden air flow 24 by the filter element 22 of the suction device 2.

[0070] Attachment of the first and second end pieces 14, 16 of the suction hose 12 to the suction opening 10 of the collection container 4 and to the air outlet 18 of the power tool 20, respectively, can be realized by means of a plug-in connection. The first and second end pieces 14, 16 can be held in place in respect to the suction opening 10 and/or the air outlet 18, respectively, by means of friction, a snap-in connection, a bayonet connection, magnetic force or the like.

[0071] It is suggested that the processing device 40 of the communication device 32 is adapted to cause the radio transmitter 38 to emit a radio signal 30 when the power tool 20 changes from a turned-off to a turned-on operating status, and that the control device 26 of the suction device 2 is adapted to switch on the vacuum generating device 8 when the radio receiver 28 receives the radio signal 30 and optionally taking into account further parameters. Additionally or alternatively, it is suggested that the processing device 40 of the communication device 32 is adapted to cause the radio transmitter 38 to emit the radio signal 30 when the power tool 20 changes from a turned-on to a turned-off operating status, and that the control device 26 is adapted to switch off the vacuum generating device 8 of the suction device 2 when the radio receiver 28 receives the radio signal 30 and optionally taking into account further parameters.

[0072] According to the invention, the vacuum generating device may be switched on without any additional delay after the sensor element 34 has detected an operation of the power tool 20 and the respective radio signal 30 has been transmitted by the radio transmitter 38 and received by the radio receiver 28 and/or to switch the vacuum generating device 8 off without any additional delay after the sensor element 34 has detected an end of operation of the power tool 20 and a respective radio signal 30 has been transmitted by the radio transmitter 38 and received by the radio receiver 28.

[0073] Preferably, at least one of switching the vacuum generating device 8 on or off is effected only after a certain time delay in respect to the detection of the start or end of operation of the power tool 20 by means of the sensor element 34 and in respect to the receipt of the respective radio signal 30 by means of the radio receiver

28 of the suction device 2. The time delay may be in the region of one to a few seconds.

[0074] To this end it is suggested that the processing device 40 of the communication device 32 is adapted to take into account as a further parameter, when causing the radio transmitter 38 to transmit a radio signal 30, a time delay between the reception of the sensor signal 36 from the sensor element 34 and the transmission of the radio signal 30 by the radio transmitter 38. Additionally or alternatively, it is suggested that the control device 26 of the suction device 2 is adapted to take into account as a further parameter, when switching on or switching off the vacuum generating device 8, a time delay between the reception of the radio signal 30 by the radio receiver 28 and the switching on or switching off of the vacuum generating device 8.

[0075] Further, it is possible that one or more unique identifiers of the participants are preset. For instance, it could be that a unique identifier of the radio transmitter 38 is preset in the radio receiver 28 or in a storage element to which the radio receiver 28 has access. Similarly, a unique identifier of the radio receiver 28 may be preset in the radio transmitter 38 or in a storage element to which the radio transmitter 38 has access to. Presetting of the unique identifiers may be realized at a factory where the participants of the radio link 30 are manufactured. Alternatively, the communication parameters and unique identifiers may be preset by a user after shipment and prior to use of the suction device 2 through a user interface 50 of the suction device 2 (see Fig. 1) and/or of the communication device 32 (see Fig. 2). Furthermore, the communication parameters and unique identifiers may be preset by a user through a mobile end user device 52 which is connected to the suction device 2 (see Fig. 1) and/or to the communication device 32 (see Figs. 2 and 3) through a further radio link 54.

[0076] When manually configuring the unique identifiers of the participants (radio transmitter 38 and the radio receiver 28) of the radio communication across the radio link 30 by a user of the suction device 2 and/or the power tool 20 after shipment and prior to use of the suction device 2, the radio link 30 is preferably configured by means of hardware and/or software of the suction device 2 and the communication device 32. A hardware configuration may comprise the setting of respective dip-switches in the radio receiver 28 and/or radio transmitter 38 or the setting of the communication parameters and/or unique identifiers through the user interface 50 making part of the suction device 2 and/or the communication device 32. A software configuration may comprise a computer program, e.g., an application or app, running on an end user device 52 and in which computer program the appropriate settings can be made and parameters and identifiers can be set. The computer program may then transmit the settings to the radio receiver 28 and/or radio transmitter 38 in order to configure the radio link 30. Transmission of the settings may be realized by means of a cable or wirelessly via a separate radio link 54. The

settings are then taken into account by the radio transmitter 38 and the radio receiver 28 during the unidirectional data transmission across the radio link 30.

[0077] Alternatively, it is also possible that the unique identifiers and/or parameters of the radio link 30 are exchanged and/or agreed upon during an establishment, start-up and/or initialization phase of the radio link 30 prior to an intended use of the data communication across the radio link 30. In that case a data transmission across the radio link 30 is exceptionally possible in both directions. However, during the intended use of the data communication across the radio link 30 when operation of the suction device 2 is controlled through radio signals transmitted from the communication device 32 across the radio link 30, the data communication is unidirectional only.

[0078] Preferably, during an initial one-time coupling process of the communication device 32 with the suction device 2, unique identifiers of the radio receiver 28 and the radio transmitter 38, parameters of the data communication across the radio link 30 and possibly other information necessary for the subsequent unidirectional data communication between the communication device 32 with the suction device 2 are exchanged across the radio link 30 exceptionally in both directions. Preferably, the exchanged identifiers, parameters and other information are stored in the respective communication device 32 and the suction device 2. Preferably, the coupling phase is initiated manually, e.g., by pressing respective coupling switches at the communication device 32 and/or the suction device 2, by the user of the power tool 20 or the suction device 2.

[0079] With the exchanged identifiers, parameters and other information stored in the respective communication device 32 and the suction device 2, a radio link 30 may be established each time the communication device 32 and the suction device 2 are supplied with power. Preferably, once supplied with power, the radio receiver 28 of the suction device 2 regularly searches for known devices, like radio transmitter 38 of the communication device 32, with which it was previously coupled, and establishes the radio link 30 thereto. Preferably, for the establishment of the radio link 30, only a unidirectional data communication across the radio link 30 is necessary,

[0080] Once the sensor element 34 senses an operation of the power tool 20, the radio transmitter 38 of the communication device 32 regularly transmits (sends) an ON-signal across the radio link 30 to the radio receiver 28 of the suction device 2. The suction device 2 or the vacuum generation device 8, respectively, is held in operation by the control device 26 as long as it regularly receives ON-signals from the radio transmitter 38. If the sensor element 34 no longer senses an operation of the power tool 20, e.g., because it has been turned off, the radio transmitter 38 no longer transmits an ON-signal and the suction device 2 or the vacuum generation device 8, respectively, is automatically turned off by the control device 26, due to a lack of an ON-signal. This provides

for a fail-safe control, in which the suction device 2 or the vacuum generation device 8, respectively, is automatically turned off, if the radio receiver 28 for whatever reason (e.g., a defect or a low battery level of the communication device 32 or a location of the communication device 32 out of range of the radio receiver 28) no longer receives ON-signals. The ON-signals are preferably transmitted across an advertising channel of the radio link 30. The transmittal of the ON-signals is effected unidirectionally across the radio link 30.

[0081] It is further suggested that the communication device 32 comprises an independent, local power supply unit 42 for providing electricity for operation of the electric components (e.g., sensor element 34, radio transmitter 38, processing device 40, user interface 50) of the communication device 32. The power supply unit 42 may comprise a rechargeable and/or replaceable battery. The power supply unit 42 could also comprise an energy transformation device, which transforms vibrations of the second end 16 of the suction hose 12 caused by the vibrating power tool 20 during its intended use into electric energy which is supplied to the battery for recharging (energy harvesting from mechanical movements) or directly to the electric components of the communication device 32. Alternatively, the energy transformation device may comprise a pneumatic generator located in the air stream 46 through the second end 16 of the suction hose 12 which will generate electric energy once the power tool 20 with a self-generated dust extraction functionality is activated and an air stream 46 is created.

[0082] Due to the fact that the communication device 32 transmits a radio signal 30 only occasionally when the operation status of the power tool 20 changes, the power supply unit 42 has an almost infinite lifetime without running out of electric energy. To this end, the energy transformation device may comprise piezoelectric materials, may be in the form of an electrodynamic or inductive generator or may be in the form of an electrostatic generator.

[0083] According to a further preferred embodiment, it is suggested that the suction device 2 has a visual and/or acoustic signalling device 44 which communicates a status of the power supply unit 42 of the communication device 32 visually and/or acoustically to a user of the suction device 2 and/or the power tool 20. The visual and/or acoustic signalling device 44 could be located at and make part of the communication device 32 assigned to the power tool 20. Preferably, the signalling device 44 is located at a top part 64 of the external housing of the suction device 2, by which the vacuum generating components (e.g., control device 26, vacuum generating device 8) of the suction device 2 are housed. This significantly enhances visibility and/or audibility by the user of the suction device 2 and/or the power tool 20. In this case, the communication device 32 or the radio transmitter 38, respectively, will communicate the current status of the power supply unit 42 to the radio receiver 28 of the suction device 2, which will forward the current status to the control device 26 which in turn will cause

the current status to be output through the signalling device 44. To this end it is suggested that a respective status message is transmitted across the radio link 30 from the radio transmitter 38 to the radio receiver 28.

[0084] The status of the power supply unit 42 preferably corresponds to a charge level of the power supply unit 42. In a simple embodiment the status could simply comprise the information whether the charge level of a battery of the power supply unit 42 is sufficient in order to assure proper functioning and full operability of the electric components of the communication device 32 (green light and/or no acoustic signal) or it is not sufficient (red light and/or flashing light and/or acoustic signal). Alternatively, different charge levels of a battery of the power supply unit 42 could provoke different visual and/or acoustic output signals by the signalling device 44. The communication device 32 may be realised in different embodiments. According to a preferred embodiment shown in Fig. 3, the communication device 32 is a self-contained unit which is detachably attached to the second end 16 of the suction hose 12, similar to a wrist watch which is attached to the wrist of a user. In particular, the communication device 32 may have a housing 88, e.g., made of a plastic or rubber material, in which all components (sensor element 34, radio transmitter 38, processing device 40, power supply unit 42, user interface 50) of the communication device 32 are located. The housing 88 may be completely sealed off, in order to provide for a moisture-proof and dust-proof encapsulation of the components. The communication device 32 may be provided with straps 90 which are looped around the second end 16 of the suction hose 12 and then fastened together, e.g., by means of a buckle, a Velcro® 92 or the like to fasten the communication device 32 to the second end 16 of the suction hose 12. Alternatively, some kind of fastening structure, e.g., a Velcro® or a snap-in structure, may be provided at the second end 16 of the suction hose 12, and the housing 88 of the communication device 32 is releasably attached to that fastening structure.

[0085] According to an alternative embodiment shown in Fig. 2, the communication device 32 is integrated in the second end 16 of the suction hose 12, preferably by means of a moulding process during manufacturing of the second end piece 16 of the suction hose 12 and/or the entire suction hose 12. According to this embodiment, the communication device 32 is an integral part of the second end piece 16 of the suction hose 12. In order to replace the communication device 32, the entire second end piece 16 and/or the entire suction hose 12 would have to be replaced. This embodiment may have considerable advantages in terms of a cost-efficient production and integration of the communication device 32 in the suction hose 12, because the second end 16 of the suction hose 12 may also serve as a housing for the communication device 32 and its components. Even if integrated into the second end 16 of the suction hose 12, the suction hose 12 or the second end piece 16, respectively, may be provided with a closable maintenance

opening which permits access to the components of the communication device 32 for repair or replacement, e.g., for replacement of a battery of the power supply unit 42 if exhausted, and/or for replacement of the radio transmitter 38 in order to change the frequency band on which the radio signals are transmitted to the radio receiver 28 across the radio link 30, and/or to switch a dip-switch or the like to set the radio transmitter 38 to another frequency for the radio communication.

[0086] The sensor element 34 for detecting the operation status of the power tool 20 may be embodied in many different ways. According to preferred embodiments, the sensor element 34 is designed as an acceleration sensor for detecting vibrations of the suction hose 12 during operation of the hand-held electric or pneumatic power tool 20 or as a flow sensor for detecting an air flow 46 in the second end 16 of the suction hose 12, which is attached to the air outlet 18 of the power tool 20, during operation of the power tool 20. An operation of the power tool 20 will inevitably lead to vibrations, which may be detected by the acceleration sensor. This is in particular the case for oscillating power tools 20, e.g., a random-orbital sander, a gear-driven sander or the like. The acceleration sensor may be in the form of a piezoelectric accelerometer. If the power tool 20 is provided with a self-generated dust extraction functionality, operation of the power tool 20 will inevitably lead to an air flow 46 of possibly dust-laden air from the working area 78 through the air outlet 18 of the power tool 20 and the second end 16 of the suction hose 12. This air flow 46 may be detected by a flow sensor. The flow sensor preferably has a measuring probe positioned in the air flow 46. The flow sensor may detect the air flow 46 optically, by means of ultra-sonic waves or other types of electromagnetic waves.

[0087] Alternatively or additionally, the sensor element 34 could also comprise an optical or other type of sensor for detecting an amount of dust and of other small particles contained in the dust laden air flow 46 passing through the second end 16 of the suction hose 12. Preferably, the sensor element 34 determines the amount of dust or other small particles per time unit. A status message containing or indicative of the determined amount of dust or small particles, preferably per time unit, could be transmitted by the radio transmitter 38 across the radio link 30 to the radio receiver 28 of the suction device 2. The rotational speed of the vacuum generating device 8 could be increased or decreased according to the determined amount of dust or small particles.

[0088] Finally, it is suggested that the suction device 2 has a main switch 48 for manually switching the suction device 2 between an operational status (I) and an inactive status (0) and that the control device 26 is designed to turn on the vacuum generating device 8 depending on an operating status of the hand-held electric or pneumatic power tool 20 to whose air outlet 18 the second end 16 of the suction hose 12 is connected, only when the suction device 2 is in an operational status (I). With other

words, by switching the suction device 2 into the operational status (I), it may be brought into a kind of standby-mode in which the vacuum generating device 8 is not yet in operation. Only if additionally, the sensor element 34 detects an operation of the power tool 20, to which the suction hose 12 is attached, will the vacuum generating device 8 be turned on. As previously mentioned, turning on the vacuum generating device 8 can be accomplished almost contemporarily with the activation of the power tool 20 or with a time delay. If the sensor element 34 detects the end of an operation of the power tool 20, the vacuum generating device 8 will be turned off. Again, this can be accomplished almost contemporarily with the deactivation of the power tool 20 or with a time delay.

[0089] The suction hose 12 according to the invention can be used with different suction devices 2 and for establishing various types of unidirectional radio links in order to transmit the radio signals across the radio link 30 according to different parameters (e.g., frequency, channel, etc.) and standards (e.g., size and format of transmitted data packets and data frames, repetition rate of data frames, etc.). The specific type of unidirectional radio link to be used may be manually set by a user, e.g., by selecting a certain unique identifier and/or communication parameters from a previously stored plurality of identifiers and/or communication parameters. Selection may be effected by means of dip-switches, by replacing one storage unit (e.g., a USB-stick, an IC, etc.) containing the selected identified and/or the selected parameters by another storage unit containing another identifier and/or other parameters, or by means of a user's mobile end user device 52 connected to the power tool 20 or the suction device 2 by means of the further radio link 54. As previously mentioned, unique identifiers and/or parameters of the radio link 30 could also be agreed upon or exchanged between the participants (radio transmitter 38 of the communication device 32 and radio receiver 28 of the suction device 2) of the radio link 30 during an establishment start-up and/or initialization phase. Agreement or exchange of the unique identifiers and/or parameters may be realized across the radio link 30, exceptionally in both directions.

[0090] Preferably, the suction hose 12 has the first end 14 adapted to be connected to the suction opening 10 of a suction device 2 and the opposite second end 16 adapted to be connected to the air outlet 18 of the hand-held electric or pneumatic power tool 20. The second end 16 comprises the communication device 32 integrated therein, preferably by means of a moulding process during manufacturing of the second end 16 of the suction hose 12 and/or the suction hose 12. The communication device 32 comprises the sensor element 34 for detecting the current operation status of the hand-held electric or pneumatic power tool 20 and for outputting the sensor signal 36 depending on the detected operating status of the power tool 20. It is suggested that the sensor element 34 is in the form of an acceleration sensor for detecting vibrations of the suction hose 12 during operation of the

hand-held electric or pneumatic power tool 2.

[0091] Thus, the invention provides for a highly integrated suction hose 12 with integrated communication device 32 for detection of the operating status of the power tool 20 to which it is attached and for transmitting the operating status or a signal indicative thereof to the radio receiver 28 of the suction device 20, wherein the type of radio transmission is limited to a unidirectional transmission during the intended use. The communication device 32 may form an integral part of the second end 16 of the suction hose 12 so that the communication device 32 is safely protected inside the second end 16 from dust, humidity and mechanical stress.

Claims

1. Suction hose (12) adapted for use with a suction device (2), in particular a vacuum cleaner or a dust extraction system, comprising a radio receiver (28) for receiving radio signals across a radio link (30), the suction hose (12) comprising a first end (14) adapted to be connected to a suction opening (10) of the suction device (2) and an opposite second end (16) adapted to be connected to an air outlet (18) of a hand-held electric or pneumatic power tool (20), and a communication device (32) located at or near the second end (16) of the suction hose (12), the communication device (32) comprising:

- a sensor element (34) for detecting a current operation status of the hand-held electric or pneumatic power tool (20) and for outputting a sensor signal (36) depending on the detected operating status of the power tool (20),
- a radio transmitter (38) for transmitting a radio signal across the radio link (30), and
- a processing device (40) which is in operative connection with the sensor element (34) on the one hand and with the radio transmitter (38) on the other hand and which is adapted to cause the radio transmitter (38) to emit a radio signal depending on a sensor signal (36) received from the sensor element (34) and optionally taking into account further parameters,

wherein the communication device (32) is designed to realise only unidirectional communication across the radio link (30) from the radio transmitter (38) of the communication device (32) to the radio receiver (28) of the suction device (2),

characterized in that manually operated switching means are assigned to the communication device (32), in particular one or more buttons, switches, keys or dials, configured to be manually actuated by a user of the power tool (20) for controlling the suc-

- tion device (2), in particular for turning on or off the suction device (2) and/or for increasing or reducing a rotational speed of a motor (68) of the suction device (2) and/or for initiating, terminating or controlling a flushing of one or more filter elements (22) of the suction device (2) by a reverse air flow, via the unidirectional communication across the radio link (30).
2. Suction hose (12) according to claim 1, **characterized in that** the manually operated switching means (94) form part of the communication device (32), the switching means (94) are adapted to create switching signals upon manual operation of the switching means (94) and to forward the switching signals to the processing device (40) of the communication device (32), the processing device (40) is adapted to create radio signals indicative of the received switching signals, and the radio transmitter (38) of the communication device (32) is adapted to realize a transmission of the radio signals to the radio receiver (28) of the suction device (2) via the unidirectional communication across the radio link (30).
 3. Suction hose (12) according to claim 1, **characterized in that** the manually operated switching means (94) form part of a remote control (102) physically separable from the communication device (32), the remote control (102) being in a data transmission connection (104) with the communication device (32), the switching means (94) are adapted to create switching signals upon manual operation of the switching means (94), the remote control (102) is adapted to transmit the switching signals to the communication device (32) via the data transmission connection (104), the processing device (40) of the communication device (32) is adapted to receive the switching signals and to create radio signals indicative of the received switching signals, and the radio transmitter (38) of the communication device (32) is adapted to realize a transmission of the radio signals to the radio receiver (28) of the suction device (2) via the unidirectional communication across the radio link (30).
 4. Suction hose (12) according to one of the preceding claims, **characterized in that** the sensor element (34) is designed as an acceleration sensor for detecting vibrations of the suction hose (12) during operation of the hand-held electric or pneumatic power tool (2), to which it is connected, or as a flow sensor for detecting an air flow (46) in the second end (16) of the suction hose (12) during operation of the power tool (2).
 5. Suction hose (12) according to one of the preceding claims, **characterized in that** the communication device (32) is integrated into the second end (16) of the suction hose (12), preferably by means of a moulding process during manufacturing of the second end (16) of the suction hose (12) and/or of the suction hose (12).
 6. Suction hose (12) according to one of the claims 1 to 4, **characterized in that** the communication device (32) is detachably attached as a self-contained unit to the second end (16) of the suction hose (12).
 7. Suction hose (12) according to one of the preceding claims, **characterized in that** the processing device (40) of the communication device (32) is adapted to cause the radio transmitter (38) to emit a radio signal (30) when the power tool (20) changes from a turned-off to a turned-on operating status, and **in that** the control device (26) is adapted to switch on the vacuum generating device (8) of the suction device (2) when the radio receiver (28) receives the radio signal (30) and optionally taking into account further parameters.
 8. Suction hose (12) according to one of the preceding claims, **characterized in that** the processing device (40) of the communication device (32) is adapted to cause the radio transmitter (38) to emit a radio signal (30) when the power tool (20) changes from a turned-on to a turned-off operating status, and **in that** the control device (26) is adapted to switch off the vacuum generating device (8) of the suction device (2) when the radio receiver (28) receives the radio signal (30) and optionally taking into account further parameters.
 9. Suction hose (12) according to one of the preceding claims, **characterized in that** the processing device (40) of the communication device (32) is adapted to take into account as a further parameter, when causing the radio transmitter (38) to transmit a radio signal (30), a time delay between the reception of the sensor signal (36) from the sensor element (34) and the transmission of the radio signal (30) by the radio transmitter (38).
 10. Suction hose (12) according to one of the preceding claims, **characterized in that** the communication device (32) comprises an independent, local power supply unit (42).
 11. Suction hose (12) according to one of the preceding claims, **characterized in that** the radio transmitter (38) of the communication device (32) is adapted to enter into a temporary exchange of unique identifiers of the participants (28, 38) of the radio link (30) and/or of communication parameters with the radio receiver (28) of the suction device (2) across the radio link (30) in both directions during an initialization or start-

up phase of the radio link (30).

12. Suction device (2), in particular a vacuum cleaner or a dust extraction system, being connected to a hand-held electric or pneumatic power tool (20) by means of a suction hose (12) according to one of the preceding claims.

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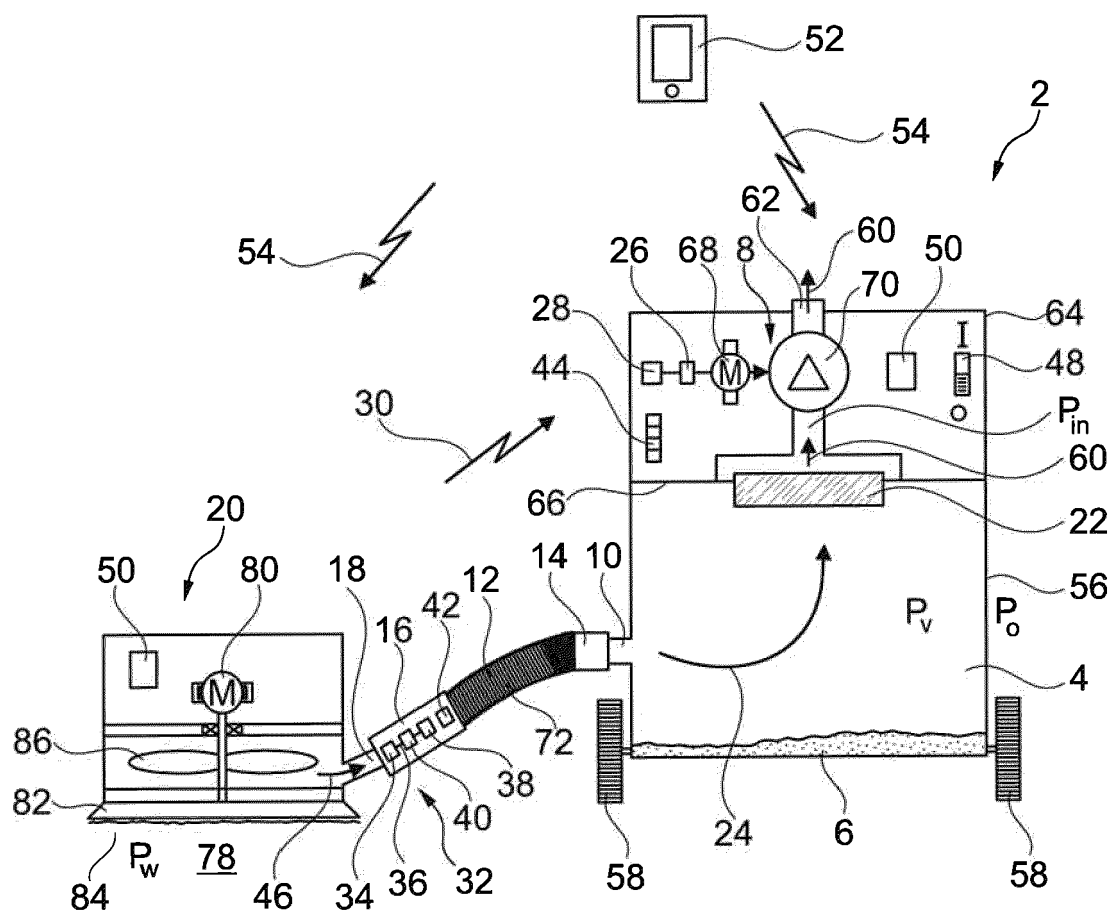


Fig. 1

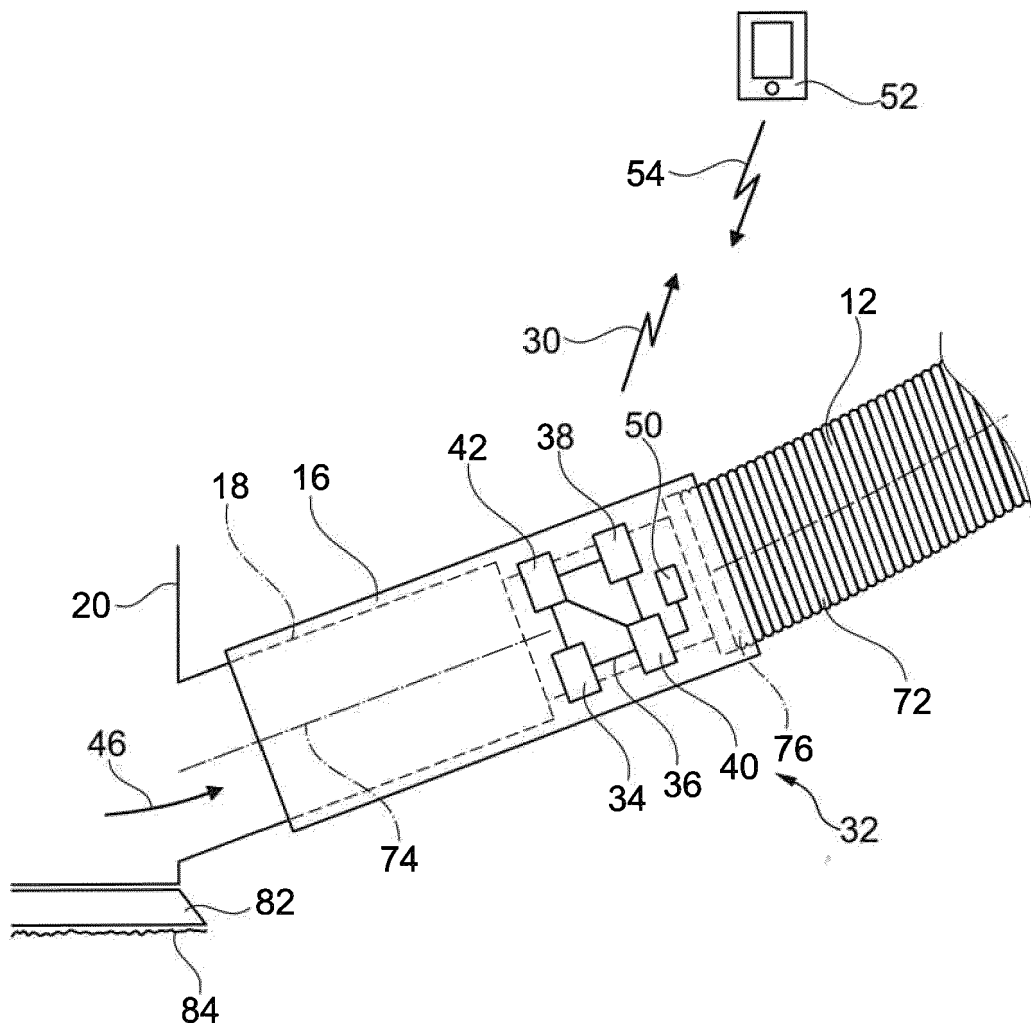


Fig. 2

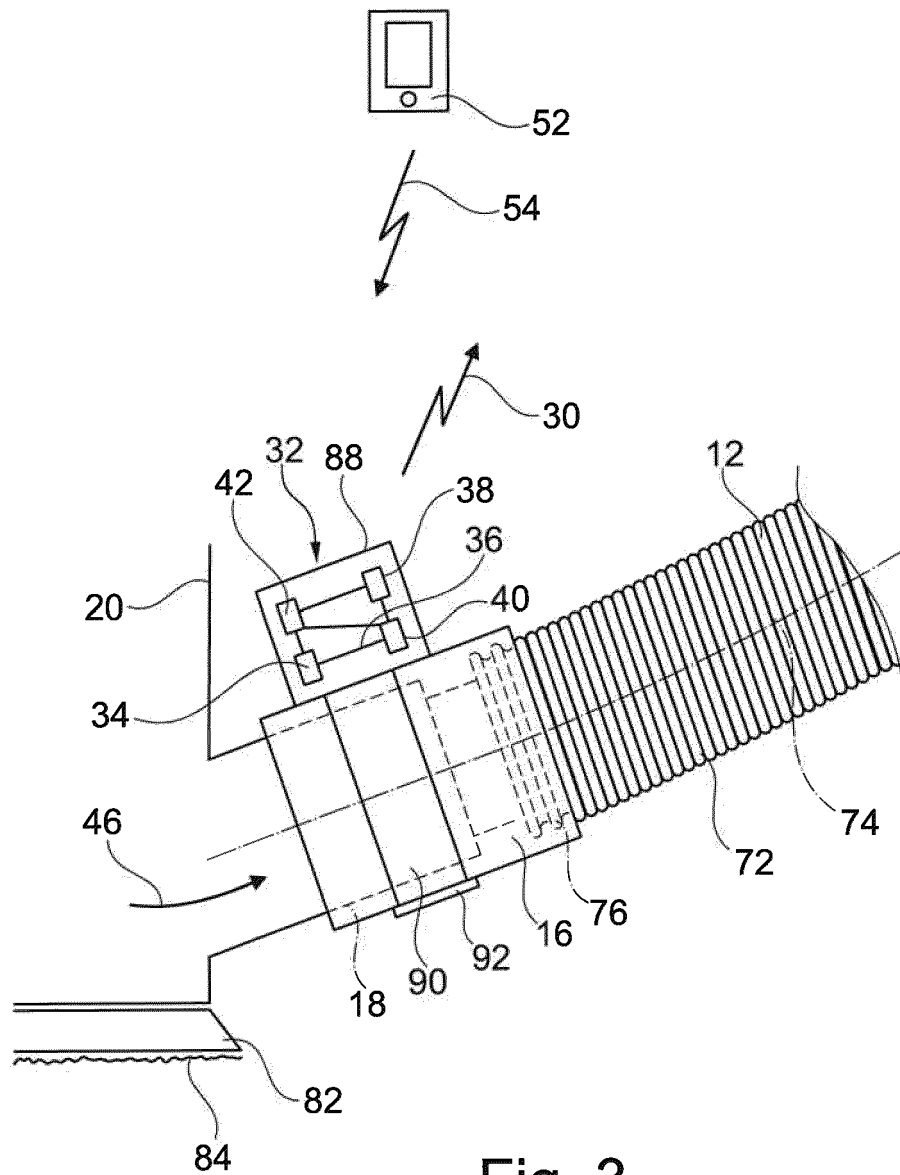


Fig. 3

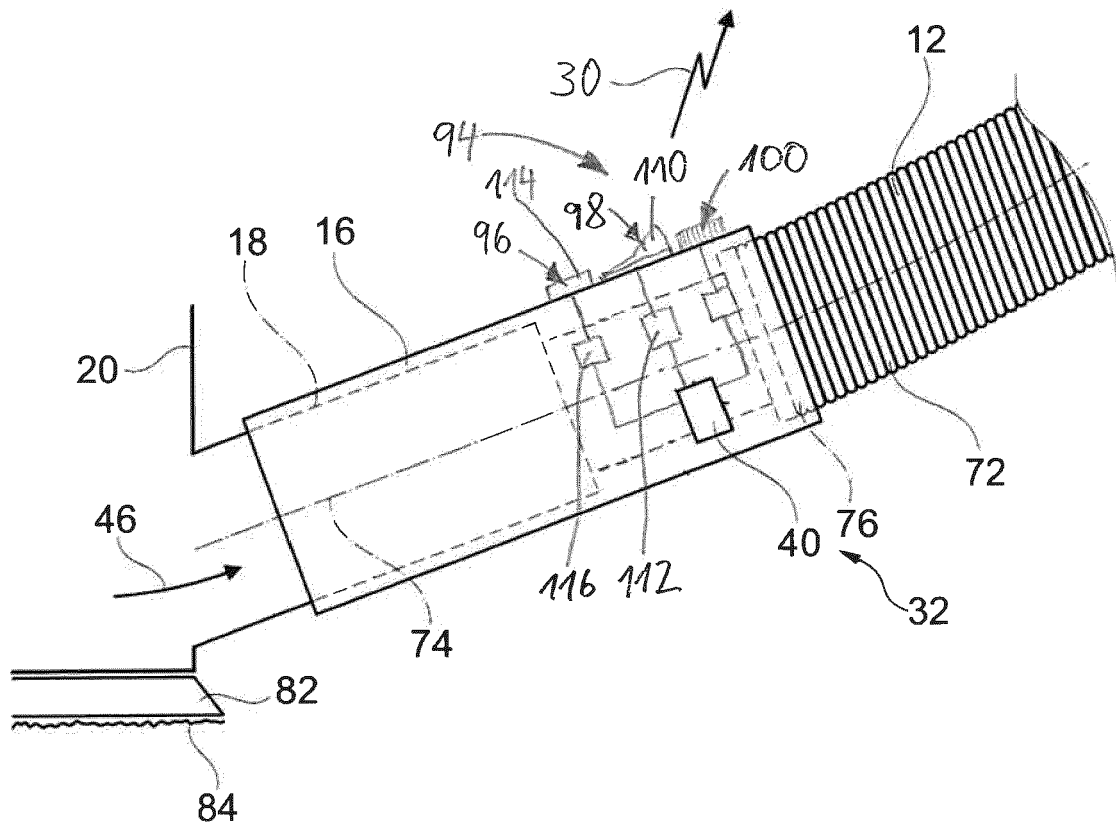


Fig. 4

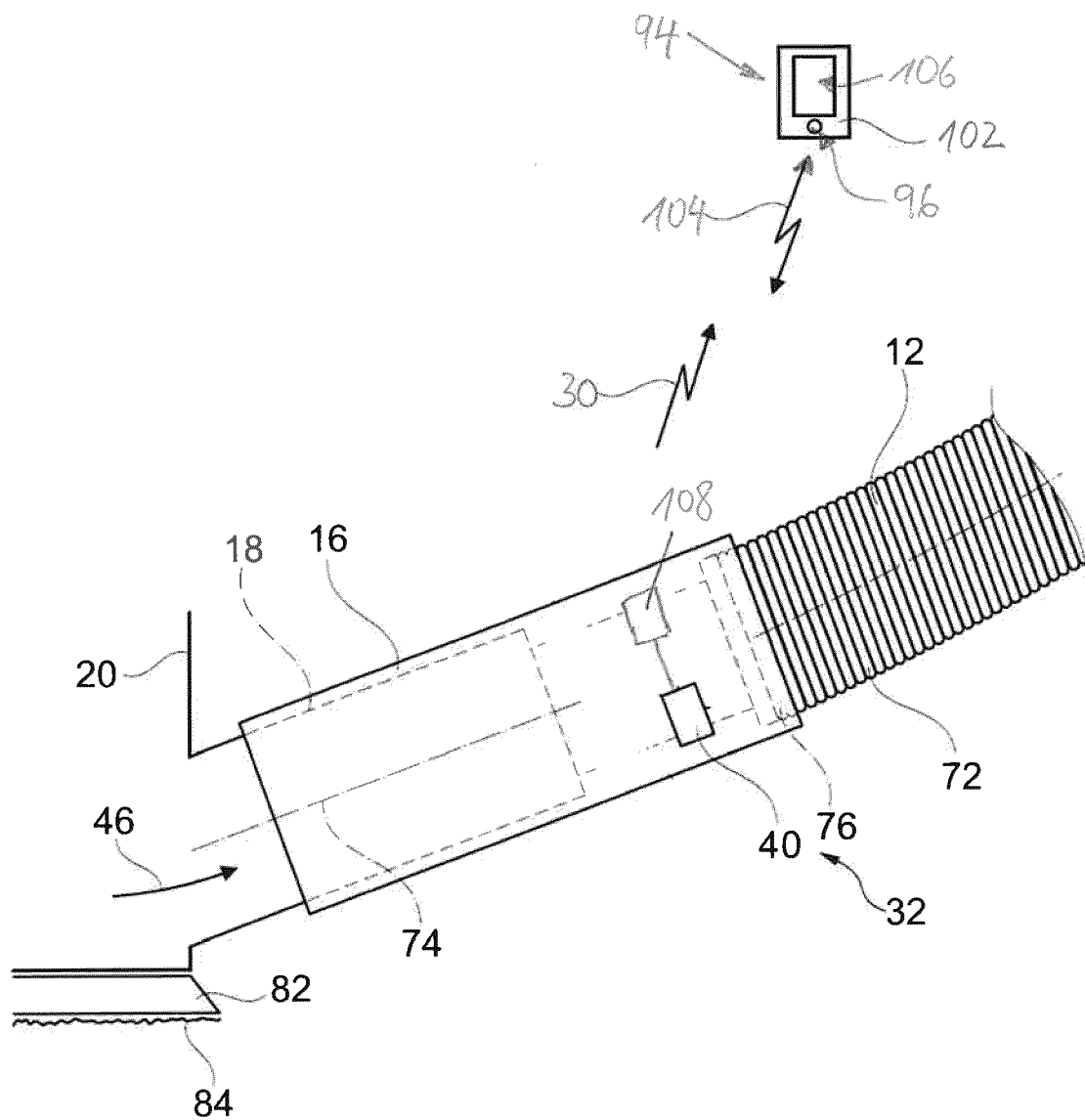


Fig. 5



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Place of search Munich		Date of completion of the search 10 July 2023	Examiner Eckenschwiller, A
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