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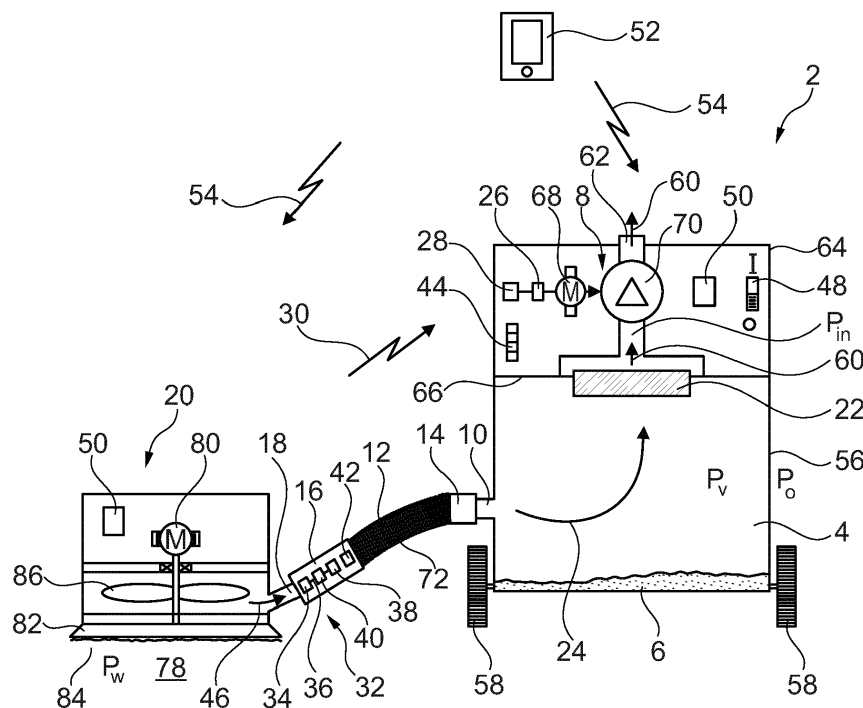
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(54) **SUCTION HOSE FOR USE WITH A SUCTION DEVICE**

(57) The invention refers to a suction hose (12) adapted for use with a suction device (2), in particular vacuum cleaner or dust extraction system, comprising a radio receiver (28) for receiving radio signals (30). The suction hose (12) comprises 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 handheld 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) is designed to realise only unidirectional communication from the communication device (32) to the suction device (2).



**Fig. 1**

## 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. The known suction device comprises:

- 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 bi-directional radio link between the communication device of the suction hose assigned to the hand-held power tool and the suction device. In this manner, it is possible to control the suction device depending on the operation status of the power tool on the one hand and to control the power tool depending on the operation status of the suction device on the other hand. 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 the bidirectional communication is necessary in order to configure, initialize and establish the radio link between the communication device assigned to the hand-held power tool and the suction device. An essential part of the establishment of the radio link is the exchange of unique identifiers of radio transmitters and radio receivers of the power tool and the suction device, respectively, as participants of the radio link. Furthermore, the establishment of the radio link comprises an exchange of initialization messages in order to determine when which participant may send and receive messages transmitted over the radio link. Summing up, the radio link with the bidirectional communication capabilities between the communication device assigned to the hand-held power tool and the suction device known from EP 2 628 427 A1 requires a large amount of resources and is rather complicated to establish.

**[0005]** Besides, configuring, initializing and establishing the radio link requires some time, which has to be waited before the bidirectional communication across the radio link is fully operational and functional. With other words, the radio link is not fully operational and functional

immediately after the suction device has been turned on, for instances by manually switching a main switch of the suction device from an inactive status to an operational status.

**[0006]** Therefore, it is an object of the present invention to provide a suction device which can more easily and more rapidly establish a radio link to a communication device associated to a hand held electric or pneumatic power tool, and which nonetheless permits control of the vacuum generating device of the suction device manually and/or depending on the current operation status of the power tool.

**[0007]** In order to solve this object, it is suggested that the communication device making part of the suction hose and associated to the hand held power tool on the one hand and the radio receiver of the suction device on the other hand are designed to realise only a unidirectional communication from the radio transmitter of the communication device to the radio receiver. In particular, it is suggested that all details of the radio link, e.g. the 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 preset prior to the intended use of the radio link and the suction device, respectively. Thus, as soon as the radio transmitter and the radio receiver are supplied with electric power and have completed their start-up procedure, during which no radio signals or messages have to be transmitted between the participants of the radio link, they are ready for radio signal transmittal or reception, respectively. In particular, the radio transmitter is ready for a radio signal transmission to the radio receiver (having a preset unique identifier) and the radio receiver is ready for a radio signal reception from the radio transmitter (having a preset unique identifier). Furthermore, the frequency range or frequency band used for the radio link, the format of signals and messages transmitted across the radio link and the protocol used for the radio signal transmission are preset in the radio transmitter as well as in the radio receiver. In particular, the hardware of the radio transmitter and radio receiver, respectively, and the software for controlling the radio signal transmission across the radio link are embodied and designed such that the radio communication with given characteristics can be effected with almost no time delay after turning on the suction device. It is further suggested that the radio communication across the radio link is effected according to a specific proprietary protocol which does not require a mutual data transmission between the radio transmitter and the radio receiver for initialization and establishment of the radio link.

**[0008]** This allows providing a radio link between the respective communication devices assigned to the power tool and the suction device, respectively, with very limited resources, a fast availability of the radio link (until full operation and function of the radio communication is reached) and an easy-to-realize unidirectional radio sig-

nal 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 establish its current operation status.

**[0009]** 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. 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.

**[0010]** Additionally, the communication device may be provided with manually operated switching means, for example one or more buttons, switches, keys or dials, which can 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 motor of the suction device and/or for initiating, terminating or con-

trolling a flushing of one or more filter elements of the suction device by a reverse air flow. Other functions of the suction device may 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 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 motor and/or increasing or reducing a rotational speed of the motor 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.

**[0011]** 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 external wheels 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.

**[0012]** 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 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.

**[0013]** 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 el-

ements 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 which 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. 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 effected, for instance, according to EP 1 997 415 A1, which is incorporated herein by reference.

**[0014]** 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.

**[0015]** 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.

**[0016]** 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.

**[0017]** 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 vacuum cleaner and to an air outlet of a power tool, respectively, is described, for example, in European application no. 20 178 759.5, which is incorporated herein by reference in its entirety.

**[0018]** 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.

**[0019]** 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.

**[0020]** 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.

**[0021]** 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.

**[0022]** 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.

**[0023]** Preferably, at least one of switching the vacuum generating device 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 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.

**[0024]** 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.

**[0025]** According to a particularly preferred embodiment of the invention it is suggested that a radio link between the radio transmitter of the communication device and the radio receiver of the suction device, across which the radio signal is transmitted, is configured at a factory as part of a manufacturing process of the suction device prior to shipment and use of the suction device. For example, the radio link may be configured prior to shipment and use by writing respective parameters (frequency, channel, signal format, protocol) of the radio link and unique identifiers of the participants of the radio communication into a storage element. The storage element may make part of the control device of the suction device and/or of the processing device of the communication device assigned to the power tool. Alternatively, the storage element may make part of the radio transmitter and/or of the radio receiver. Upon power-up of the communication device and the suction device, the stored parameters and identifiers are loaded into the radio transmitter and/or of the radio receiver so that the radio link is immediately established according to the preset parameters and identifiers and that the radio communication is effected according to the predefined format/protocol and between the predefined participants. No initialization messages have to be exchanged between the participants of the radio communication in order to establish the radio link and perform the radio communication.

**[0026]** 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. The radio link of the present invention is similar to and works similar to a uni-directional remote control for TVs and HiFi-appliances.

**[0027]** Further, it is suggested that a unique identifier of the radio transmitter is preset in the radio receiver at the factory and that a unique identifier of the radio receiver is preset in the radio transmitter at the factory. Alternatively, the communication parameters and unique identifiers may be preset 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 commu-

nication 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 device 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 uni-directional data communication between the communication device of the suction hose and the radio receiver of the suction device across the radio link.

**[0028]** 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.

**[0029]** 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 effected by means of a cable or wireless.

**[0030]** 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.

**[0031]** 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.

**[0032]** 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.

**[0033]** 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 second 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.

**[0034]** 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.

**[0035]** 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.

**[0036]** 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.

**[0037]** 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.

**[0038]** 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.

**[0039]** 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 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 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.

**[0040]** 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.

**[0041]** 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.

**[0042]** 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 (and not bidirectional) communication from the radio transmitter 38 of the communication device 32 to the radio receiver 28. 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 30 and messages, and a protocol used for transmission of the radio signals 30, may be preset prior to the intended use of the radio link 30 and the suction device 2, respectively. 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, during which no radio signals 30 or initialization messages have to be transmitted between the participants 38, 28 of the radio link 30, they are ready for radio signal transmittal or reception, respectively.

**[0043]** In particular, the radio transmitter 38 is ready for the transmission of a radio signal 30 to the radio receiver 28 (having a preset unique identifier) and the radio receiver 28 is ready for a reception of a radio signal 30 from the radio transmitter 38 (having a preset unique identifier). Furthermore, the frequency range or frequency band used for the radio link 30, the format of signals and messages transmitted across the radio link 30 and the protocol used for the transmission of the radio signals 30 may be preset in the radio transmitter 38 as well as in the radio receiver 28. In particular, 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 are embodied and designed such that the radio transmission with given characteristics can be effected with almost no time delay after turning on the suction device 2 and the communication device 32. It is further suggested that the radio communication across the radio link 30 is effected according to a specific

proprietary protocol which does not require a mutual data transmission between the radio transmitter 38 and the radio receiver 28 for initialization and establishment of the radio link 30.

**[0044]** 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.

**[0045]** 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.

**[0046]** 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.

**[0047]** 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.

**[0048]** 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.

**[0049]** 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).

**[0050]** 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.

**[0051]** 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.

**[0052]** 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.

**[0053]** 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.

**[0054]** 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.

**[0055]** 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.

**[0056]** 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.

**[0057]** 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.

**[0058]** According to a particularly preferred embodiment of the invention it is suggested that a radio link between the radio transmitter 38 of the communication device 32 and the radio receiver 28 of the suction device 2, across which the radio signal 30 is transmitted, is configured at a factory as part of a manufacturing process of the suction device 2 prior to shipment and use of the suction device 2. For example, the radio link may be configured prior to shipment and use by writing respective parameters (frequency, channel, signal format, protocol) of the radio link and unique identifiers of the participants 38, 28 of the radio communication into a storage element. The storage element may make part of the control device 26 of the suction device 2 and/or of the processing device 40 of the communication device 32 assigned to the power tool 20. Alternatively, the storage element may make part of the radio transmitter 38 and/or of the radio receiver 28. Upon power-up of the communication device 32 and the suction device 2, the stored parameters and identifiers are loaded into the radio transmitter 38 and/or of the radio receiver 28 so that the radio link is immediately established according to the preset parameters and identifiers and that the radio communication is effected according to the predefined format/protocol and between the predefined participants 38, 28. No initialization messages have to be exchanged between the participants 38, 28 of the radio communication in order to establish the radio link and perform the radio communication.

**[0059]** Further, it is suggested 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 at the factory and that a unique identifier of the radio receiver 28 is preset in the radio transmitter 38

or in a storage element to which the radio transmitter 38 has access at the factory. 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.

**[0060]** 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. 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 effected 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 data transmission across the radio link 30.

**[0061]** 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.

**[0062]** 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.

**[0063]** 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.

**[0064]** 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.

**[0065]** 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. 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.

**[0066]** 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 30 are transmitted to the radio receiver 28, and/or to switch a dip-switch or the like to set the radio transmitter 38 to another frequency for the radio communication.

**[0067]** 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 electro-magnetic waves.

**[0068]** 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.

**[0069]** 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.

**[0070]** The suction hose 12 according to the invention can be used with different suction devices 2 and for establishing various types of uni-directional radio links in order to transmit the radio signals 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 uni-directional 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.

**[0071]** 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.

**[0072]** 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 uni-directional transmission, which has the following advantages:

- radio link is ready for data communication immediately after power-up,
- no set-up or initialization procedure required before data communication across the radio link,
- manual configuration of the radio link is possible (for use of the suction hose 12 with different suction devices 2 and radio receivers 28, respectively),

**[0073]** The communication device 32 is 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 (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 (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 a sensor signal (36) received from the sensor element (34) and optionally taking into account further parameters,

**characterized in that** the communication device (32) is designed to realise only unidirectional communication from the radio transmitter (38) of the communication device (32) to the radio receiver (28) of the suction device (2).

2. Suction hose (12) according to claim 1, **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).
3. Suction hose (12) according to claim 1 or 2, **characterized in that** the communication device (32) is integrated into the second end (16), 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).
4. 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.
5. 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 pa-

rameters.

6. Suction hose (12) according to one of the preceding claims, **characterised 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).
7. Suction hose (12) according to one of the preceding claims, **characterised in that** a unique identifier of the radio receiver (28) of the suction device (2) is preset in the radio transmitter (38) of the communication device (32).
8. Suction hose (12) according to one of the preceding claims, **characterised in that** a radio link between the radio transmitter (38) of the communication device (32) and the radio receiver (28) of the suction device (2), by means of which the radio signal (30) is transmitted, is configured at a factory as part of a manufacturing process of the suction device (2) and/or the suction hose (12) prior to shipment and use of the suction device (2) and the suction hose (12), respectively.
9. Suction hose (12) according to one of the claims 1 to 7, **characterised in that** a radio link between the radio transmitter (38) of the communication device (32) and the radio receiver (28) of the suction device (2), by means of which the radio signal (30) is transmitted, is manually configured by a user after shipment and prior to use of the suction device (2), in particular by means of a user interface of the power tool (20) or of the suction device (2) or by means of a mobile end user device (52) connected to the suction device (2) by means of another radio link (54).
10. Suction hose (12) according to claim 9, **characterised in that** the radio link between the radio transmitter (38) of the communication device (32) and the radio receiver (28) of the suction device (2) is manually configured by the user by means of hardware and/or software.
11. Suction hose (12) according to one of the preceding claims, **characterised in that** the communication device (32) comprises an independent, local power supply unit (42).
12. Suction hose (12) according to one of the preceding claims, **characterised in that** the communication device (32) is detachably attached as a self-contained unit to the second end (16) of the suction hose (12).

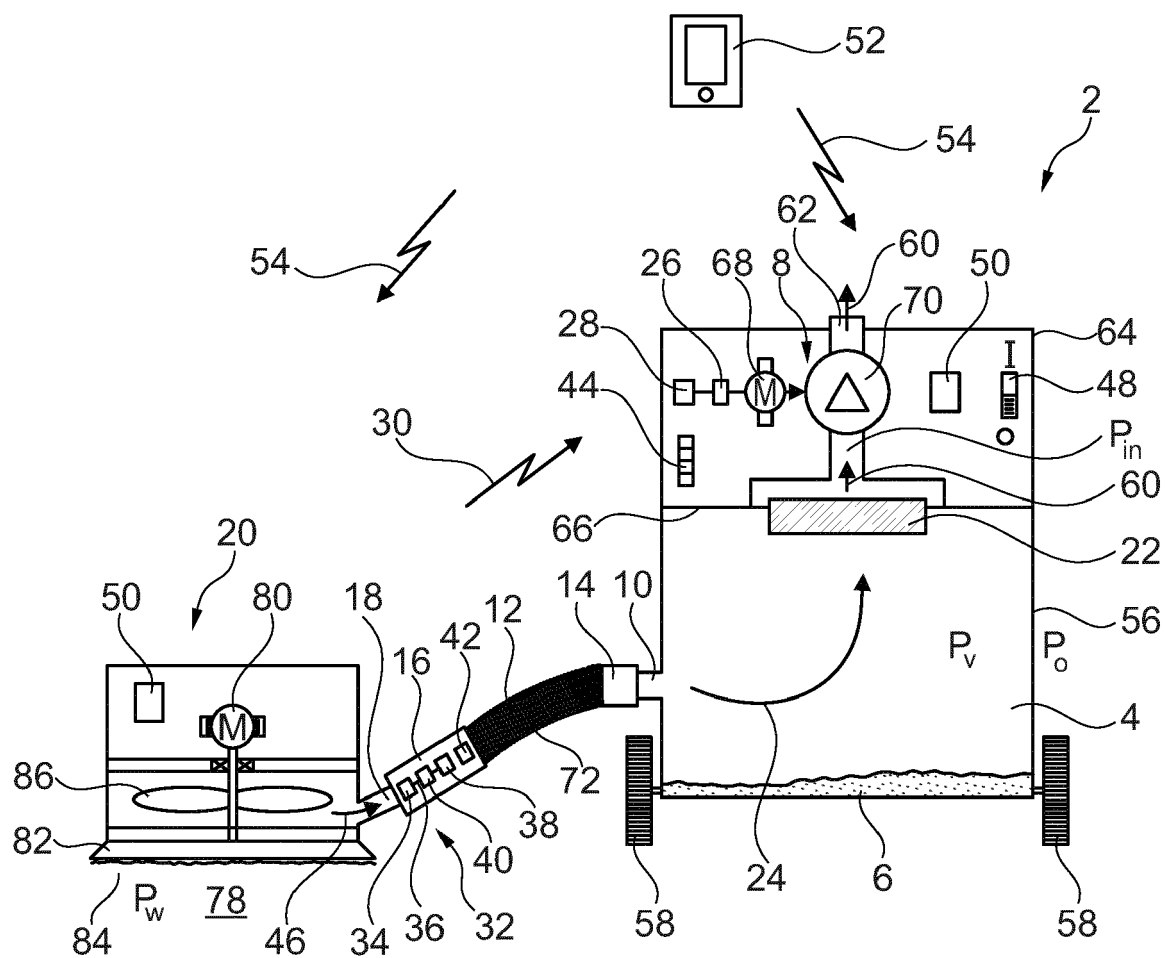


Fig. 1

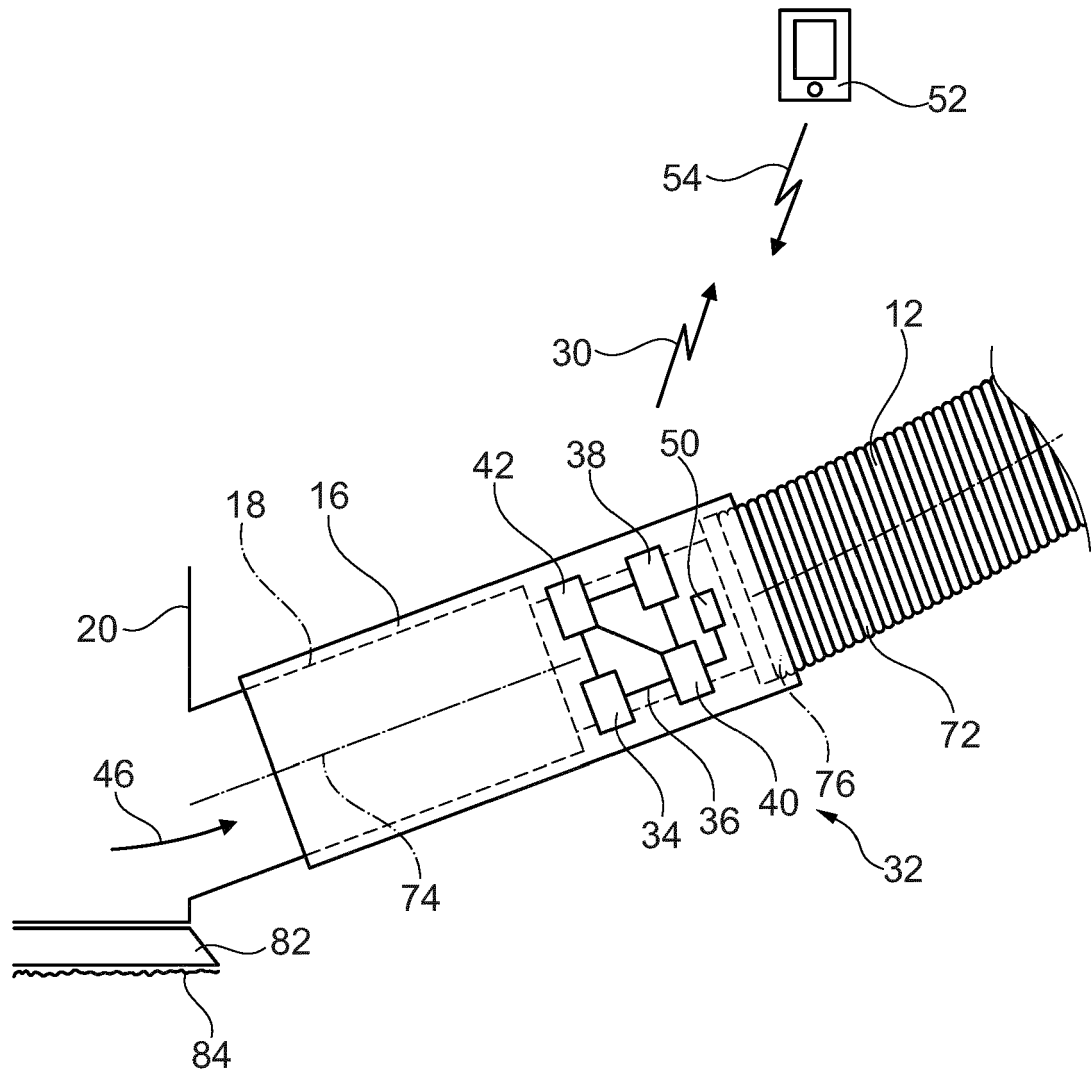


Fig. 2

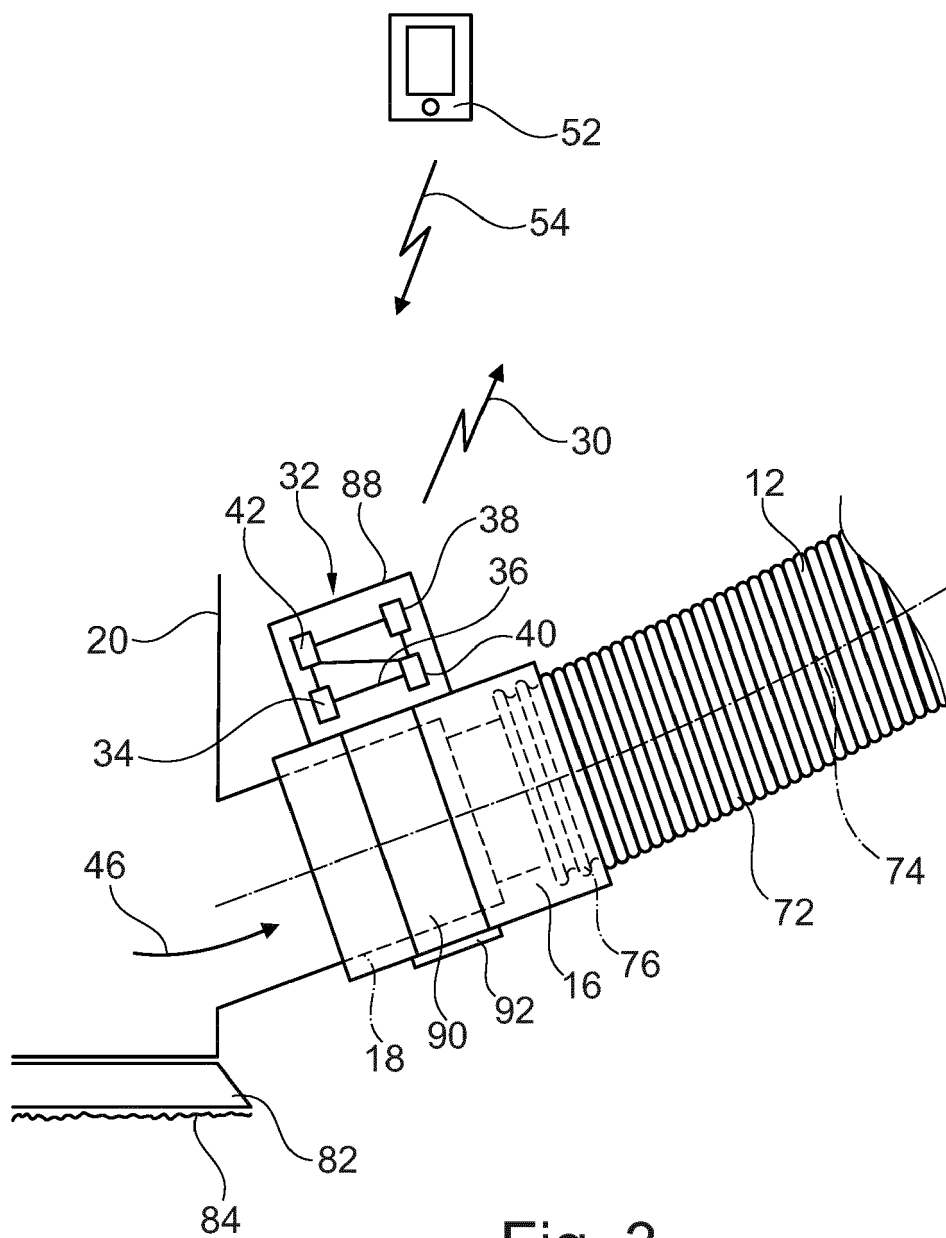


Fig. 3



## EUROPEAN SEARCH REPORT

Application Number

EP 22 15 9177

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|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|--------------------------------------|
| Place of search<br><b>Munich</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Date of completion of the search<br><b>19 August 2022</b> | Examiner<br><b>Eckenschwiller, A</b> |
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ON EUROPEAN PATENT APPLICATION NO.**

EP 22 15 9177

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