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(54) **SANDING SYSTEM**

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(57) **ABSTRACT**

A sanding system has a sanding device with a carriage, and a control unit configured so that it carries out unmanned steering of the sanding device by controlling the carriages

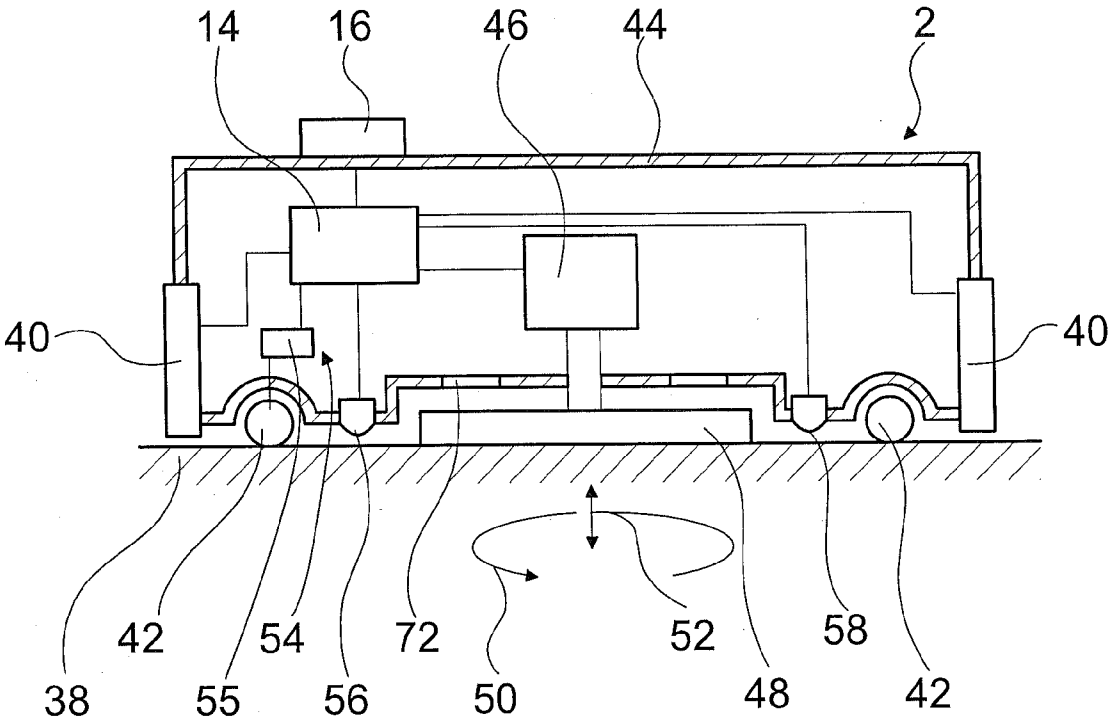


Fig. 1

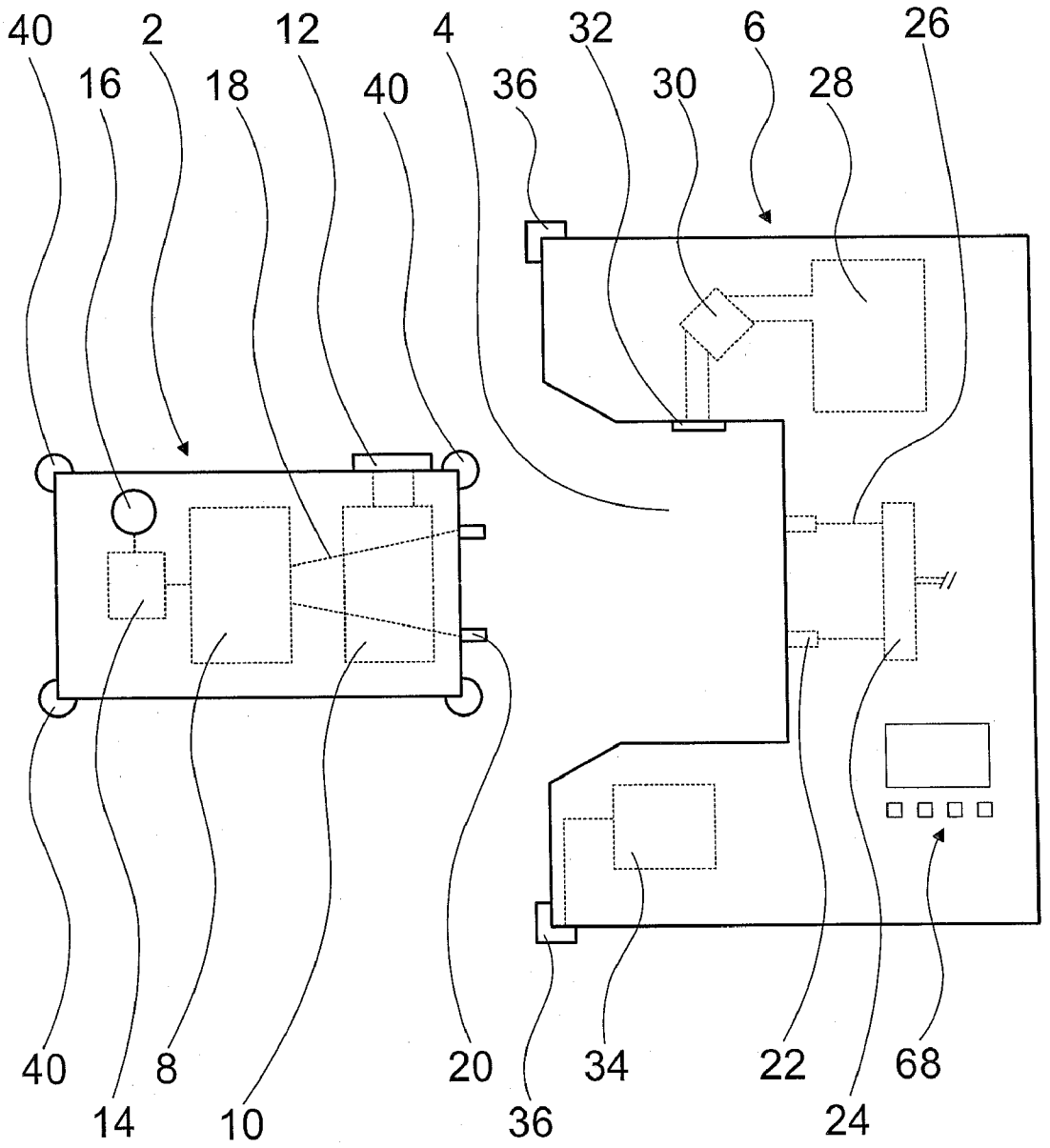
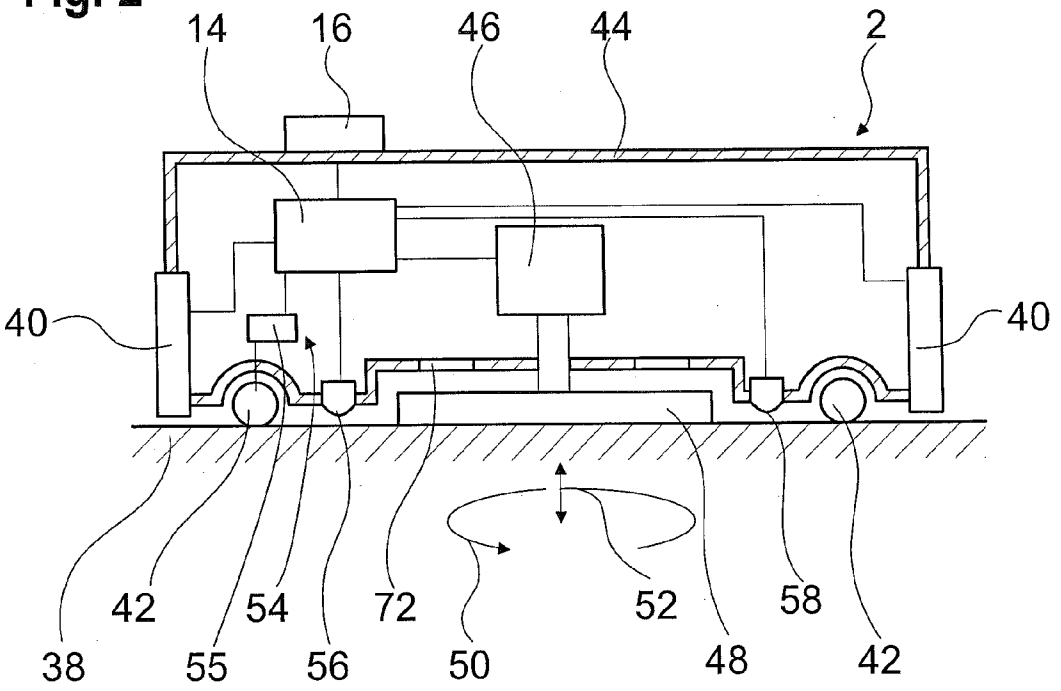


Fig. 2


14
16
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44
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42
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72
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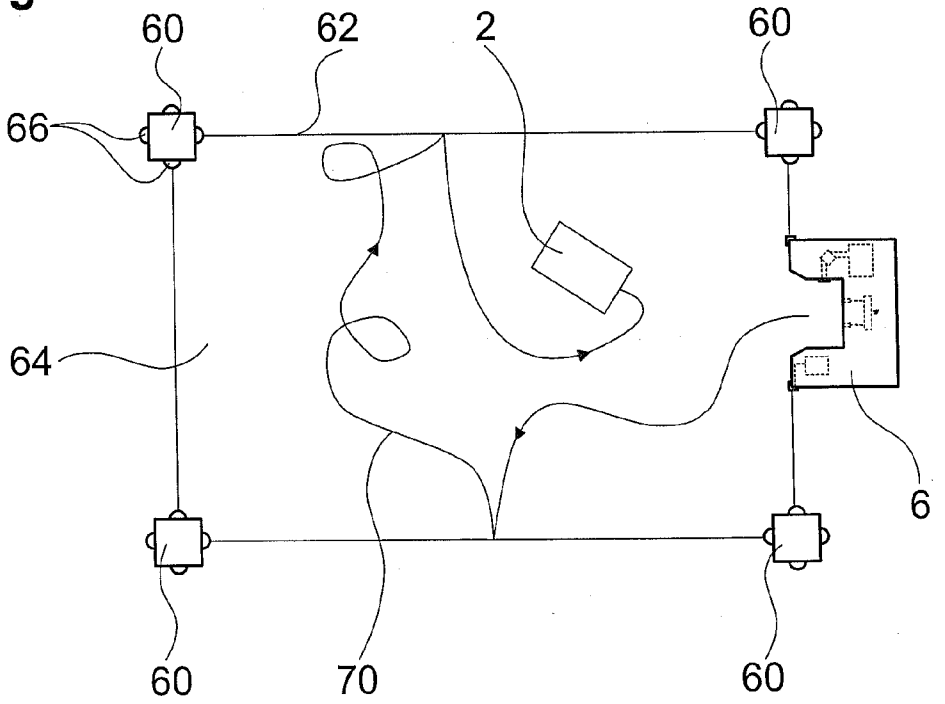
48
42

Fig. 3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2
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SANDING SYSTEM

CROSS-REFERENCE TO A RELATED APPLICATION

[0001] The invention described and claimed hereinbelow is also described in German Patent Application DE 102005062587.8 filed on Dec. 27, 2005. This German Patent Application, whose subject matter is incorporated here by reference, provides the basis for a claim of priority of invention under 35 U.S.C. 119(a)-(d).

BACKGROUND OF THE INVENTION

[0002] The present invention relates to a sanding system.

[0003] Jobs involving sanding of woods or metals are typically done with a hand sanding device, such as an orbital sander, eccentric sander, belt sander, delta sander, or the like, in which a user holds the sanding device with his hands and guides it over the surface to be sanded. Sanding jobs are often tedious and monotonous and create a great deal of noise and dirt.

SUMMARY OF THE INVENTION

[0004] Accordingly, it is an object of the present invention to provide a sanding system which eliminates the disadvantages of the prior art.

[0005] In keeping with these objects and with others which will become apparent hereinafter, the present invention deals with a sanding system having a control unit and a sanding device with a carriage.

[0006] It is proposed that the control unit be prepared for unmanned steering of the sanding device by control of the direction of motion. The sanding device can be guided along a surface to be sanded without the aid of a user, and thus the user can be relieved of a noisy, tiresome job. Automatic, unmanned sanding can be achieved by means of the sanding device. The control unit is expediently prepared for the control in such a way that the sanding device moves, unmanned, performing sanding along a sanding path that is monitored by the control unit. The sanding path can be predetermined or can be a random sanding path that is monitored by the control unit by simulation.

[0007] The control of the carriage can include regulation, for instance in that a job outcome is detected and the motion is regulated in accordance with progress of the job. The sanding device is expediently battery- or rechargeable-battery-operated (accumulator-operated). Especially advantageously, the sanding device is a hand power tool that is intended for manual operation by a user. Thus the sanding device can be used both automatically and manually, for instance for postmachining, without having to use two different devices for the purpose.

[0008] In an advantageous feature of the invention, the control unit is located in a separate station from the sanding device and is prepared for remote control of the carriage. The sanding device can be embodied in a simple and sturdy way and can be replaced inexpensively, with the intelligent control unit remaining in the station. The station is expediently provided for a stationary location relative to a workpiece to be machined. The remote control can be done by means of infrared, radio, or radar radiation, with suitable transmitters and sensors.

[0009] Long-term operation of an accumulator-operated sanding device can be attained if the sanding system includes a separate station from the sanding device, having a power supply unit, and if the control unit is provided for producing a power supply connection between the sanding device and the power supply unit. The sanding device can be moved toward the station and the power supply connection can be made and an accumulator of the sanding device can be automatically recharged without requiring any intervention on the part of a user. The power supply can be a mains connection with a power supply network, with or without an interposed transformer. A powerful accumulator in the station is equally conceivable.

[0010] Expediently, the sanding device includes an integrated vacuum cleaning action by means of a vacuum cleaning means, so that soiling of the environment can be counteracted and as a result reliable operation of the sanding system can be achieved. Unmanned evacuation of a dust holder of the sanding device can be attained if the sanding device has a dust holder, and the control unit is provided for-controlling an evacuation of the dust holder. To that end, an evacuation unit, such as a slide or a blower, may be present in the sanding device or in the station. Advantageously, there is a dust collection container in the station. By means of a fill level sensor for the dust holder, the control unit can automatically tell when evacuation is necessary. The sanding device can drive automatically to the station and transfer the dust there.

[0011] In a further advantageous embodiment of the invention, the sanding system includes a limiting transducer, which specifies a barrier of a sanding region, and by a signal transducer for outputting a signal if the barrier is crossed. A sanding region can be specified by a user or by the control unit, and the sanding device automatically stays inside this sanding region. The limiting transducer can include a mechanical barrier, for instance in the form of a wall, or it may be provided for producing a radiation boundary, for instance by means of a beam or a curtain of infrared or radar radiation. A sensor element can detect the mechanical barrier or boundary or radiation boundary and cause the signal transducer to output the signal, for instance to the control unit. The control unit can also serve as the signal transducer that sends a suitable signal, for instance for turning the sanding device around, to the carriage.

[0012] A good sanding outcome can automatically be achieved if various sanding modes are stored in memory and the control unit, and the control unit is provided for an automatic selection of a sanding mode. Expediently, the control unit is provided for automatically changing among sanding modes, particularly as a function of a detected outcome of sanding.

[0013] A high degree of safety of the sanding system can be attained if the control unit is provided for an automatic shutoff of a sanding unit upon lifting of the sanding device. This can be attained by means of a contact sensor, which mechanically, electrically, or by means of radiation monitors a contact of the sanding device with the workpiece. As a result, if the sanding device falls down from the workpiece, this can be detected and the sanding unit can be shut off.

[0014] A good outcome of sanding can be attained by means of a measuring means for measuring a removal of material attained by a sanding operation. The sanding opera-

tion can be monitored, and excessive removal of material can be avoided. The measuring means can be a dust sensor, for instance in the form of an optical photoelectric barrier. By means of a measuring means for measuring a depth or a thickness, the thickness of a layer of material removed, or of the remaining workpiece, can be measured and the sanding operation can be adapted accordingly. By means of a measuring means for measuring a surface quality of a workpiece to be machined, the sanding operation can be adapted directly to the surface, and for instance by means of an input unit, a surface quality that is automatically established can be input. The surface quality may be a waviness, roughness, or hardness of the workpiece.

[0015] If the carriage includes rollers for moving the sanding device, then the sanding device can be moved especially simply. The rollers can be wheels, in particular steerable wheels. A very flexible, fast, and easily controlled two-dimensional motion can be achieved if the rollers are balls. The balls can be driven by two motors, each being responsible for a motion in one direction.

[0016] Further advantages will become apparent from the ensuing description of the drawings. In the drawings, exemplary embodiments of the invention are shown. The drawings, description and claims include numerous characteristics in combination. One skilled in the art will expediently consider the characteristics individually as well and put them together to make useful further combinations.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] FIG. **1**, a sanding system, with an automatically controlled sanding device and with a station, in accordance with the present invention;

[0018] FIG. **2**, the sanding device in a schematic sectional view, in accordance with the present invention; and

[0019] FIG. **3**, a sanding region, adjusted by limiting transducers and within which the sanding device moves, in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0020] FIG. **1** shows a sanding device **2** in front of a receiving opening **4** of a station **6**. The sanding device **2** includes a rechargeable battery or accumulator **8** for supplying it with operating current; a dust holder **10**, which is connected to a transfer element **12**; and a control unit **14**, which is connected to a transceiver unit **16**. The accumulator **8** is connected via lines **18** to two plugs **20**, which are intended to be plugged into corresponding outlets **22** in the station **6** and are connected to a power supply unit **24**. The power supply unit **24** is embodied as a transformer, which is connected to a mains connection, not shown, via lines **26**. A dust holder **28** and an evacuation unit **30**, in the form of a blower which is connected to a transfer element **32**, are also located in the station **6**. The station **6** further includes a control unit **34**, which is connected to two transceiver units **36**. The control unit **34** serves the purpose of remote control of the sanding device **2**.

[0021] FIG. **2** shows the sanding device **2** on a workpiece **38**, in a schematic sectional view. Optical sensors **40** are located at four outer corners and each form the farthest-outward elements of the sanding device **2**. Alternatively, mechanical sensors may be used. Located inside a housing **44** of the sanding device **2** are the control unit **14**; the dust holder **10**, not shown in FIG. **2** for the sake of simplicity; and a motion unit **46**, which is provided for rotating a sanding element **48**, as indicated by an arrow **50**, and for raising and lowering the sanding element **48**, as represented by an arrow **52**, or pressing it against the workpiece **38**.

[0022] The sanding element **48** has a sanding medium which includes granular sanding particles that are sintered or melted into a metal plate. Because of the metal substrate, the sanding element **48** is very long-lived and does not quickly become clogged. The sanding element **48** can be operated by the motion unit **46** like an orbital sander or eccentric sander, or it can sand by means of a fast, light oscillating motion.

[0023] Also located inside the housing **44** is a schematically shown carriage **54**, with a motor **55** that drives balls **42** for moving the sanding device **2**. The sanding device **2** can have four or more balls, only two of which are shown in FIG. **2**. The drive of each ball is done two-dimensionally, so that the sanding device **2** can drive both forward and in reverse as well as laterally and in all the directions located between these, without having to make any turns. A depth sensor **56** and a surface sensor **58** are located on the bottom of the housing **44** and are each connected to the control unit **14**.

[0024] FIG. **3** shows the sanding device **2**, the station **6**, and four optical limiting transducers **60**, which define a sanding region **64** by means of four barriers **62** generated from infrared radiation. The limiting transducers **60** were placed on the workpiece **38** by a user, and they each include four transceiver units **66** for receiving and sending infrared light.

[0025] For sanding the workpiece **38**, the station **6**, sanding device **2** and limiting transducer **60** are placed on the workpiece **38** and switched on, and a sanding mode is set by a user, via an input **63** in the station **6**. After a starting command has been input via the input unit **68**, the control unit **34**, via the transceiver units **36**, causes encoded infrared radiation to be emitted, which strikes at least one transceiver unit **66** of the adjacent limiting transducer **60** and is recorded there. As a result, the limiting transducers **60** are activated and in turn, via a transceiver unit **66**, send infrared radiation to the next limiting transducers **60**, which as a result are likewise activated, and so on, until the infrared radiation reaches the respective other transceiver unit **36** of the station **6** and is recorded by the control unit **34**. It is thus assured that the infrared fence all the way around the sanding region **64** is closed.

[0026] The control unit **34** now, via one of the transceiver units **36**, sends a starting signal to the receiver **16** of the sanding device **2**, and this signal is processed by the control unit **14**. This signal contains not only the previously input sanding mode but also a sanding path **70** to be taken by the sanding device **2** and the starting signal for the sanding device **2** for moving and sanding.

[0027] The sanding device **2** now takes up its sanding activity and drives, performing sanding, along the sanding path **70**, defined by the control unit **34**, around the workpiece **38** in the sanding region **64**, as indicated in FIG. **3**. The sanding path **70** defined by the control unit **34** may be a systematic path, or as shown in FIG. **3**, a random path.

[0028] The sensors **40** are signal transducers for outputting a signal if the barrier **62** is crossed. Each time the infrared

beam of the barrier **62** strikes one of the sensors **40**, a command to turn the sanding device **2** around, or make a major change in its direction, is issued. In an alternative example, the barrier may be a mechanical barrier, and the optical sensors **40** may be mechanical sensors, advantageously a soft ring extending all the way around the sanding device **2**—similar to a vehicle bumper—which when the mechanical barrier is used damps a collision of the sanding device **2** with the barrier.

[**0029**] During sanding, material is removed from the workpiece **38** by the sanding element **40** and is transported into the dust holder **10** through openings **72** in the housing **44**, via a suction device, not shown. By means of a fill level **20** sensor, not shown, the fill level of the dust holder **10** is monitored by the control unit **14**. If the dust holder **10** is filled up to a predetermined limit value, then the control unit **14** issues a corresponding signal to the control unit **34**, which directs the sanding device **2** into the receiving opening **4** of the station **6**.

[**0030**] As a result of the travel of the sanding device **2** into the receiving opening **4**, the transfer elements **12**, **32** are placed against one another, and then the blower of the evacuation unit **30** is started, and an evacuation of the dust holder **10** is begun. Also by the entry of the sanding device **2** into the receiving opening **4**, the plugs **20** are introduced into the outlets **22**, and the accumulator **8** is recharged. After sufficient evacuation and recharging operations, the control unit **34** causes the sanding device **2** to travel back out again, and the sanding process is resumed.

[**0031**] With the aid of the depth sensor **56** and the surface sensor **58**, the workpiece **38** is monitored continuously during the sanding operation. For instance, if a set-point thickness of the workpiece **38** has been specified by a user by means of an input in the input unit **68**, then the workpiece **38** is correspondingly monitored by the depth sensor **56**. If the actual thickness approaches the set-point thickness, then a contact pressure of the sanding element **48** against the workpiece **38** is reduced at the applicable point, and as a result of this change in the sanding mode, only slight removal of material from the surface of the workpiece **38** is accomplished.

[**0032**] At thicker points of the workpiece **38**, the contact pressure is increased, and more material is removed. At points where the set-point thickness is reached, the contact pressure of the sanding element **48** on the workpiece **38** is reduced to zero, and further removal of material is thus prevented. Corresponding sanding modes are stored in memory in the control unit **14** or in the control unit **34**, and the control unit **14** or **34** as applicable is prepared for an automatic selection of an advantageous sanding mode.

[**0033**] If a surface quality has been specified by the user, the surface of the workpiece **38** is monitored by the surface sensor **58**, and the sanding mode is adapted to suit the surface. In the case of a rough surface, for instance, the contact pressure is increased, while with a smooth surface, the contact pressure is reduced. Alternatively, a sanding speed or a vibration frequency can be varied, so that the desired outcome of sanding is reached quickly and precisely. If in a different machining mode, only a quantity of material to be removed is specified by a user, then the removal of material attained during the sanding operation can be monitored by either the depth sensor **56** or the surface sensor **58** or both.

[**0034**] By means of a dust sensor, not shown, in the region of the openings **72**, a removal of material from the workpiece **38** can additionally be ascertained, and with the aid of the control unit **14**, a conclusion can be drawn as to whether the sanding element **48**, for instance when sanding paint, has become clogged, and as a consequence the removal of material is only very slight. By means of a change of sanding mode caused by the control unit **14**, for instance to a slower motion of the sanding element **48** with a higher pressure on the workpiece **38**, further clogging of the sanding element **48** can be counteracted, and the sanding element **48** may possibly be cleaned again.

[**0035**] By means of the depth sensor **56**, the spacing of the sanding device **2** from the workpiece **38** is also monitored. If this spacing exceeds a predetermined value, a signal accordingly from the depth sensor **58** is assessed by the control unit **14**, and both the carriage **54** and the motion unit **46** are switched off. As a result, upon lifting of the sanding device **2**, the sanding element **48** and travel by the sanding device **2** are automatically switched off.

[**0036**] As an additional safety mechanism, a contact pressure of the balls **42** is measured in an undercarriage, not shown, and if one of the balls **42** is hanging in the air, the control unit **14** detects this. A user can decide whether in such a case the carriage **54** and the motion unit **46** should be shut off, thus preventing the sanding device **2** from falling down from the workpiece **38**. In the case of very uneven workpieces, this safety precaution can be brought about for instance not until at least two or more balls **42** are hanging in the air.

[**0037**] In an alternative feature, the control of the carriage **54** can be controlled directly by the control unit **14**, which monitors the unmanned steering of the sanding device **2**, for instance along a sanding path **70** that is monitored by the control unit **14**. The control unit **14** in this case controls only the limiting transducers **60** and the elements of the station **6**.

[**0038**] It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of constructions differing from the type described above.

[**0039**] While the invention has been illustrated and described as embodied in a sanding system, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

[**0040**] Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. A sanding system, comprising a sanding device with a carriage; and a control unit configured so that it carries out unmanned steering of said sanding device by controlling said carriage.

2. A sanding system as defined in claim 1; and further comprising a station which is separate from said sanding device, said control unit being located in said separate station and configured for remotely controlling said carriage.

3. A sanding system as defined in claim 2, wherein said separate station has a power supply unit, said control unit being configured for providing a power supply connection between said sanding device and said power supply unit.

4. A sanding system as defined in claim 1, wherein said sanding device has a dust holder, said control unit being configured for controlling an evacuation of said dust holder.

5. A sanding system as defined in claim 1; and further comprising a limiting transducer which specifies a barrier of a sanding region; and a signal transducer for outputting the signal if the barrier is crossed.

6. A sanding system as defined in claim 1, wherein said control unit has a memory in which various sanding modes are stored, said control unit being configured for an automatic selection of a respective one of said sanding modes.

7. A sanding system as defined in claim 1, wherein said control unit is configured for an automatic shutoff of a sanding unit upon lifting of said sanding device.

8. A sanding system as defined in claim 1; and further comprising a measuring means for measuring a removal of material attained by a sanding operation.

9. A sanding system as defined in claim 1; and further comprising a measuring means for measuring a depth.

10. A sanding system as defined in claim 1; and further comprising measuring means for measuring a surface quality of a workpiece to be machined by said sanding device.

11. A sanding system as defined in claim 1, wherein said carriage has rollers for moving said sanding device.

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