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(54) **ROBOTIC SURFACE TREATING DEVICE WITH NON-CIRCULAR HOUSING**

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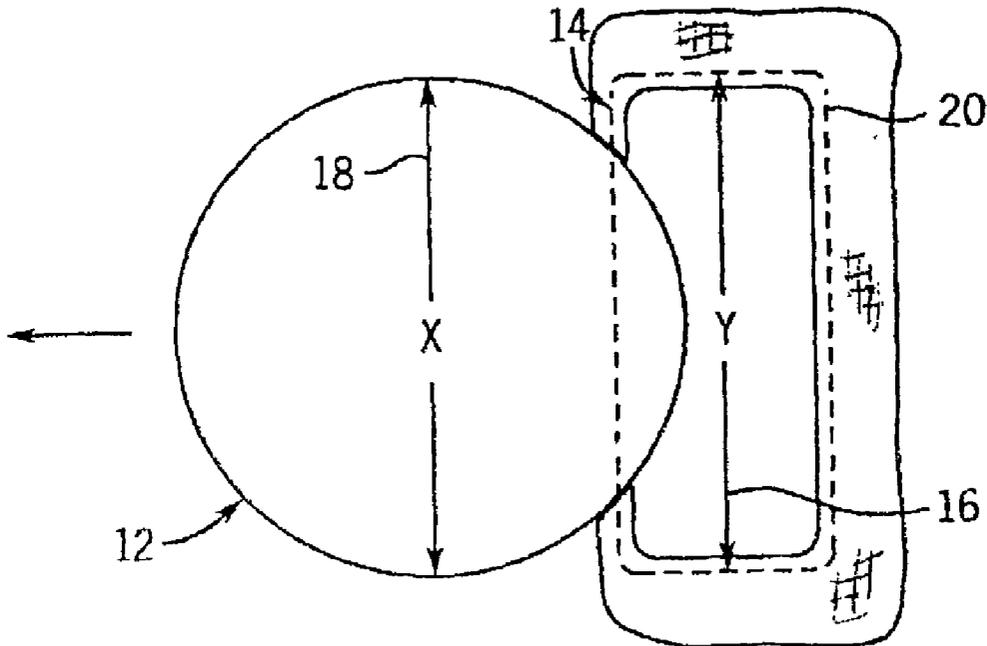
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(57) **ABSTRACT**

A robotic cleaning device includes a housing having a rounded leading portion and a non-circular trailing portion. The width of the trailing portion is no greater than that of the leading portion. The trailing portion can have an electrostatic skirt or bottom cover for cleaning a surface. The skirts can be in the form of a disposable ruffle.

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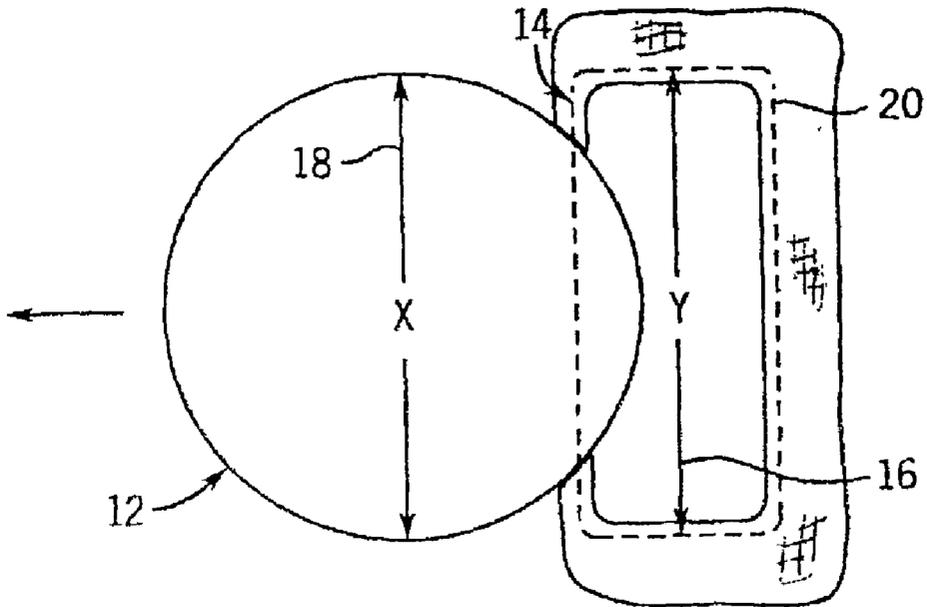


FIG. 1

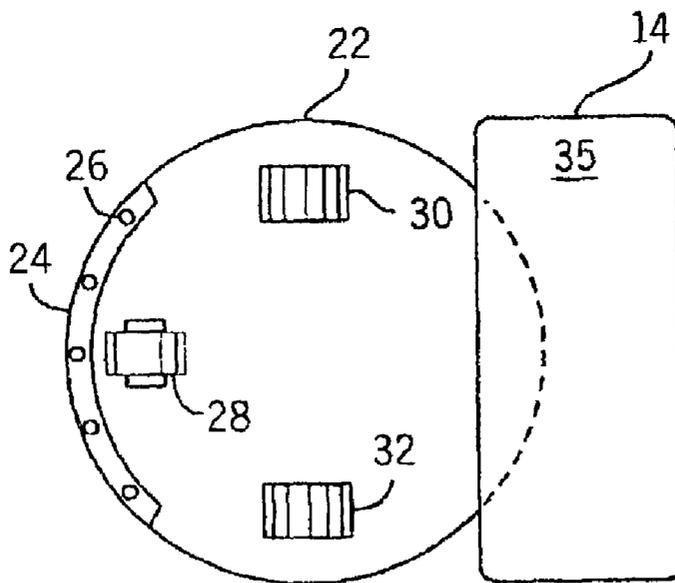
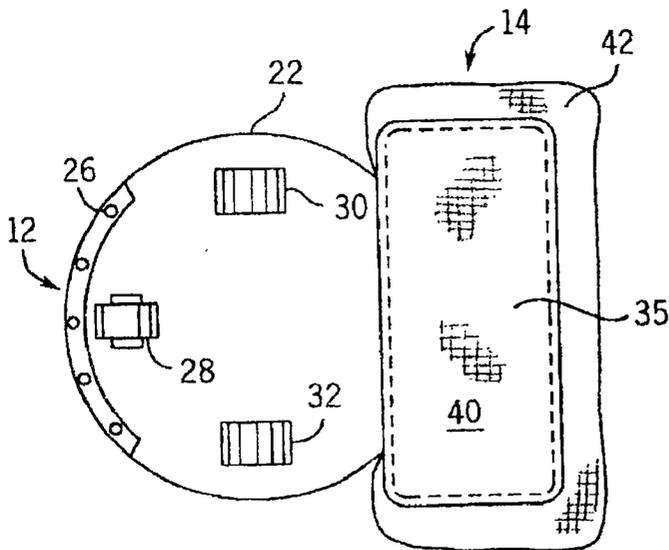
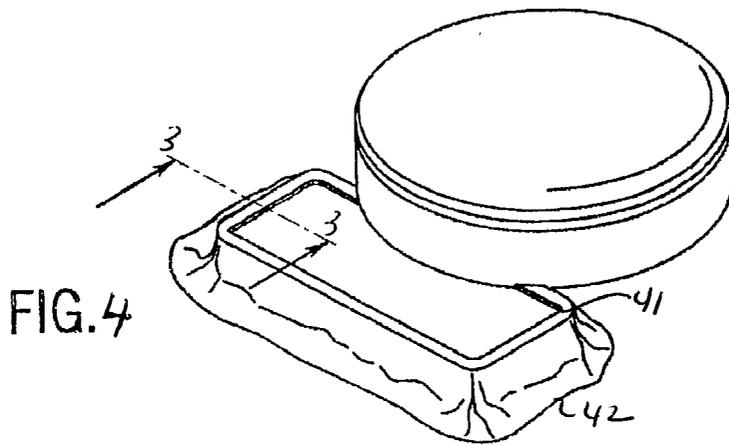
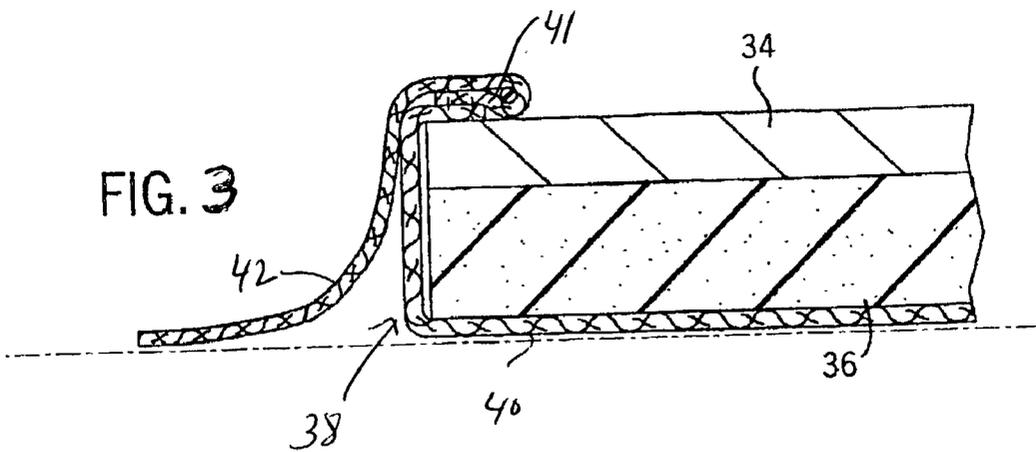


FIG. 2



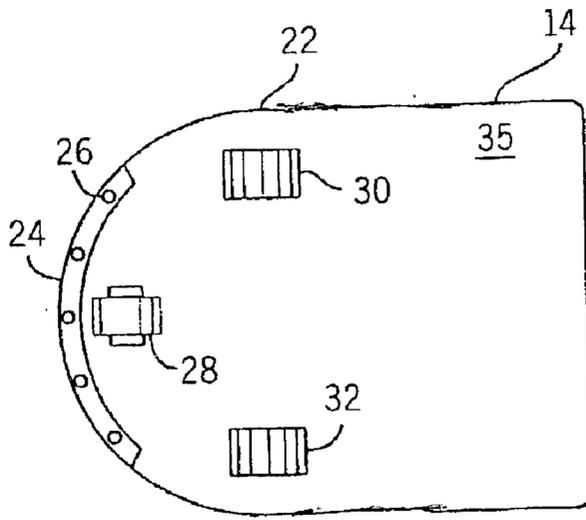


FIG. 6

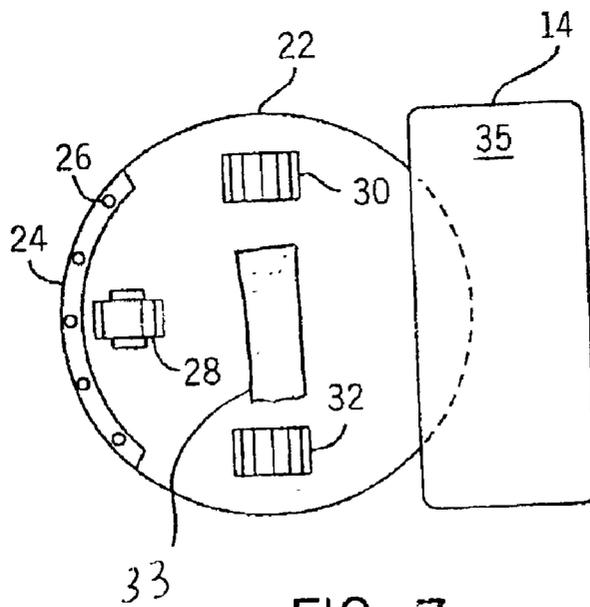


FIG. 7

## ROBOTIC SURFACE TREATING DEVICE WITH NON-CIRCULAR HOUSING

### CROSS REFERENCE TO RELATED APPLICATIONS

[0001] Not applicable

### STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH/DEVELOPMENT

[0002] Not applicable

### BACKGROUND OF THE INVENTION

[0003] It is desirable to minimize the amount of human labor expended in maintaining and cleaning residential and commercial spaces. The art has therefore developed robotic devices that can clean or otherwise maintain or treat floors, carpeting, lawns or the like without the necessity for a human to be present during the operation of the device. The most common robotic devices of this kind are dusters, buffers, vacuum cleaners, floor sweepers, other floor polishers, automated mowers and automated dispensers of agricultural products.

[0004] Such devices typically have a computer control program to direct a preferred movement pattern. The control is linked to steering devices as well as motors that are in turn connected to wheels. Many of these devices also include sensors to confirm the initial and later positions of the device relative to the pre-set path. The most sophisticated of these devices include sensors to detect the presence of unexpected obstacles, as well as programming to provide options for altered paths where that occurs. An example of a prior art control system for such a robotic system is disclosed in U.S. Pat. No. 4,119,900.

[0005] Some robotic cleaning devices are generally circular. However, these tend to leave significant untreated areas adjacent walls or furniture.

[0006] Still other devices have a circular front end and generally linear housing across a trailing end. See U.S. Pat. Nos. 5,621,291 and 5,646,494. In these devices brushes for vacuuming a floor are located in the center of a cleaning robot, between a powerless rear stability wheel and powered front wheels. The primary cleaning element is in any event located a distance from the perimeter or edge of the cleaning robot. Thus, even though the non-circular portion is the widest portion of the design, there will still be a space between the cleaning element and nearby objects such as a wall, chair, table leg or other obstacle encountered while cleaning. Such devices therefore do not optimally clean around these types of surfaces and obstacles, and require a separate manual operation near them, regardless of the accuracy of the programming.

[0007] Other autonomous cleaning devices have both a circular body portion and a non-circular body portion. They typically position a control and drive system in the circular portion, and a cleaning device in or on the non-circular portion. However, the non-circular portion is made wider than the diameter of the circular portion and therefore extends significantly horizontally outward from the sides of the circular robot body to provide a wide back or trailing end.

[0008] These devices are well suited to clean along the perimeters of walls. Such devices include those shown in U.S. Pat. Nos. 5,894,621, 5,998,953, 6,119,057, and 6,142,252. However, because the trailing end of these devices is wider than the diameter of the circular main housing, as the robot turns through a corner or around furniture the trailing end can become lodged between adjacent walls or on a furniture leg if the device is slightly off its expected path.

[0009] Still other configurations for robotic cleaners have been developed. See e.g. those described in U.S. Pat. Nos. 5,309,592, 5,440,216, and 5,720,077. However, none adequately addresses all of the concerns expressed above with respect to such robotic devices.

[0010] In sum, a need still exists to provide improved robotic surface treating devices, particularly those that can effectively clean in and around gaps, irregular surfaces, angled surfaces and corners, with reduced tendency to become hung up on encountered surfaces.

### SUMMARY OF THE INVENTION

[0011] The present invention provides a robotic surface treating device such as a vacuum cleaner, floor polisher, floor waxer, lawn mower, or dispenser of agricultural materials. There is a housing having a leading portion that is rounded along its periphery in top view and a trailing portion that is non-circular along at least a portion of its periphery in top view.

[0012] The leading portion houses a control system for directing movement of the robotic cleaning device, and the trailing portion is linked to a surface contact element. The trailing portion has a widest side-to-side width which is equal to or less than the widest side-to-side width of the leading portion.

[0013] In preferred forms the device is a duster and the surface contact element is a dust sheet/dust ruffle combination where the combination is made of a cleaning cloth which can be an electrostatic or dust-attractant material. The dust sheet is positioned so as to contact a surface being treated by the device when the device is moved over the surface, and the ruffle also contacts the ground when present along the rear and sides of the trailing portion.

[0014] In other preferred forms the ruffle is impregnated with at least one of a fragrance, an insecticide, an insect repellent, a polish, or a cleaning fluid, and thus acts to also dispense materials thereby treating the surface and/or the surrounding environment. In one form the trailing portion is constructed to provide pressure on the dust sheet to assist its contact with a surface to be treated by the device.

[0015] While the duster is a preferred form, the device might also be selected from the group of vacuum cleaners, floor polishers, floor waxers, mowers and dispensers of agricultural chemicals.

[0016] Another form of the invention is a disposable dust ruffle for use with such devices. The ruffle has an essentially cup-shaped portion made at least in part of an electrostatic material, a fastener attached along an upper rim of the cup, and a skirt made at least in part of an electrostatic material and extending radially outward and downward from the upper rim of the cup. The ruffle may also have the fastener be an elastic band.

[0017] Another aspect of the invention is to provide methods for using the above devices to clean a surface.

[0018] Because the device has a trailing portion which is no wider than the leading portion, the device is resistant to becoming hung up on furniture legs or at corners. Further, the rounded nature of the front of the device provides an opportunity for the device to avoid furniture legs, while the less round nature of the trailing section insures coverage along walls. Also, the electrostatic nature of the skirt insures that the region between the edge of the contact element (e.g. the rotary brush) and the housing outer surface will be treated.

[0019] The bottom of the trailing section can be provided with a plate having a soft cover made of rubber, foam or other material which expands and contracts depending on the shape of the surface being cleaned. In such a case, the contact element can be a sheet of the electrostatic material in total, or in part. Further, the skirt can be an additional section of the electrostatic material.

[0020] The skirt can be a dust-attracting material sized and dimensioned to be stretch-fit over the trailing portion of the robotic cleaning device. In such a case, a rotary brush need not be used and there can be a central portion and a skirt. The central portion encloses a bottom surface of the non-circular portion of the robot to provide a cleaning function on the floor, and the skirt extends outwardly and downwardly from the periphery of the trailing portion. The skirt attracts dust and particulate matter from the surface surrounding the robotic cleaning device where traditional cleaning elements do not reach.

[0021] This brief summary of the invention has been provided so that the general nature of the invention may be readily understood. However, neither this summary, nor the attached drawings, nor the description of the preferred embodiments which follows, should be construed to limit the invention. Rather, the claims should be looked to in order to assess the full scope of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0022] FIG. 1 is a top plan view of a robotic cleaning device constructed in accordance with the present invention;

[0023] FIG. 2 is a bottom plan view thereof;

[0024] FIG. 3 is a partial sectional view taken along line 3-3 of FIG. 4;

[0025] FIG. 4 is an lower rear perspective view of a dust cover for use with the present invention; and

[0026] FIG. 5 is a bottom plan view similar to FIG. 2, but of the device after the FIG. 4 dust cover has been installed.

[0027] FIG. 6 is a bottom plan view of a robotic leaning device constructed in accordance with a second embodiment of the present invention.

[0028] FIG. 7 is a bottom plan view of the robotic cleaning device 6f FIG. 1, illustrating a brush cleaning element.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0029] A robotic cleaning device 10 in the form of a cleaner or surface treating device is disclosed. It has a

forward, generally circular top view, housing portion 12, and a trailing, generally non-circular top view, housing portion 14. Portion 12 houses a computer controller, a motor, a steering mechanism, and linkages to the drive wheels 30 and 32. Portion 14 is generally rectangular in shape, with the side-to-side width Y/16 of the trailing housing portion no greater than with the side-to-side width X/18 of the front housing portion. Corners 20 of the non-circular portion 14 may be slightly rounded such that, in operation, contact with surfaces such as walls, table legs, chair legs, etc. does not result in a dent, scratch or other damage. Although the robotic cleaning device 10 is shown as having two separate pieces, it will be apparent that the circular and non-circular portions can be constructed as a single piece (See FIG. 6). Furthermore, the non-circular portion 14 can be constructed to be wider than the portion 12, and in this configuration a spring mechanism or other device for retracting the sides of the trailing portion 14 to provide and to reduce the width when the device is stuck or otherwise caught in a corner or other small partially enclosed area.

[0030] A skirt 42 in accordance with the present invention is constructed of cleaning cloth which can comprise, for example, a dust-attractant material or a cloth impregnated with a treating material such as a cleaning fluid or other treating fluid as described below. The skirt 42 extends around and from the non-circular portion 14 of the robotic cleaning device. There can also be a cushioning bumper 24 with a plurality of sensors 26.

[0031] In the well known manner the control and drive system can include programming, circuitry and linkages for determining a route for the robotic cleaning device based on a pre-programmed route, as well as providing feedback loops and corrections based thereon. The wheels 28, 30, and 32 permit the device to roll over most essentially flat surfaces, with the rear wheels 30 and 32 providing traction and the front wheel 28 being pivotable to provide steering.

[0032] The non-circular trailing portion 14 comprises a plate 34 that can be constructed of a heavy material to provide a selected pressure on the surface to be dusted (e.g. it can be made of steel, fiberglass, or another heavy plastic). To prevent scuffing of some surfaces (e.g. polished wood floors), there can be a compressible material 36 such as a foam rubber provided on a bottom side of the plate 34. The soft facing material 36 is preferably sized and dimensioned to cover the plate 34, and may be coupled to the plate 34 with an adhesive or other material.

[0033] Cleaning cloth 38 is sized and dimensioned to be stretch-fit over the trailing portion 14. It has a central sheet 40 sized and dimensioned to enclose facing material 36, as well as an elongated elastic material 41 surrounding the perimeter of the central sheet 40. There is also a hanging skirt portion 42 that extends radially outward from the elongated elastic material 41 to drag along the floor. Thus, a dusting effect occurs along the central sheet 40; and any dust kicked up by the movement of the device tends to be trapped by the trailing skirt 42.

[0034] Moreover, as the skirt is bunched like a dust ruffle it can wedge into room corners and close to table legs and pick up dust from those areas even though the main dusting portion 40 never rides over those areas. Thus, the device improves the coverage of a dusting system.

[0035] Although shown to cover only the trailing portion 14, it will be apparent that the cleaning cloth 38 could cover the entire bottom of the device 10.

[0036] The cleaning cloth 38 is constructed from a cleaning cloth material, and can comprise an electrostatic or electret material. Examples of such materials are those described in WO 02/00819, the publication for PCT/US00/20074 filed Jun. 22, 2001. This disclosure is incorporated herein by reference for a description of these types of materials. The cleaning cloth 38 can also provide a treating or dispensation function. For example, the cleaning cloth can be treated cleaning fluid or polishes to treat the floor, with insecticides, insect repellants, and fragrances to be dispersed to a room, or with a combination of these treating elements. Furthermore, various sections of the cleaning cloth 38 can comprise different types of material, providing, for example, a cleaning section and a polishing section. Other combinations will be apparent.

[0037] It should be appreciated that the dust attractant materials employed in the present invention will attract dust even when not in contact with them. This is to be distinguished from a mere adhesive which preserves contact once made, but does not attract contact from a distance. Furthermore, the cleaning cloth material is typically disposable, but can also be a reusable material which can be cleaned or washed and reused.

[0038] As noted above, the cleaning cloth 38 can also be impregnated with a polish, fragrance, insecticide, insect repellent cleaning fluid or other material. In such embodiments the device can provide both a cleaning function and a treating function. Alternatively, the cleaning cloth 38 can be designed specifically to disperse treating elements in the room, as noted above.

[0039] Referring next to FIG. 5, the cleaning cloth 38 is shown installed on the device. The central portion 40 encloses the bottom cleaning surface 35, and the skirt 42 extends radially from both the right and left sides and from the back of the non-circular portion 14.

[0040] In operation, as the robotic device 10 traverses a floor or other surface to be cleaned, the central sheet 40 of the cleaning cloth 38 is applied to the floor or surface in order to pick up dust and other particulate matter. The weight of plate 34 of the non-circular portion 14 applies a pressure on the central sheet 40 of the cleaning cloth 38. In some applications (See FIG. 7), the robotic device 10 can also include a rotary or other brush-driven cleaning element 33. In this application, particulate matter collected by the brush can be directed to a location under the cleaning cloth 38, wherein the cleaning cloth 38 provides an additional function of collecting particulate matter.

[0041] As the robotic cleaning device 10 turns to the left or right, the proximity sensors and control system determine a path which maximizes coverage. For example, when the circular section approaches a corner the device may turn to project towards the corner the rectangular section.

[0042] While a dusting device has been shown, the principles of the present invention should apply to vacuum cleaners, floor polishers, lawn mowers, and a wide variety of other surface treating equipment. Thus, although specific embodiments of the present invention have been described

in detail, it should be understood that this description is merely for purposes of illustration.

[0043] Various modifications of these embodiments may be made without departing from the spirit or scope of the following claims. Thus, the claims should be looked to in order to assess the full scope of the invention.

#### Industrial Applicability

[0044] Disclosed are improved robotic surface treating devices, methods for using them, and dust ruffles for use therewith.

What is claimed is:

1. A robotic surface treating device, comprising:

a housing having a leading portion that is rounded along its periphery in top view and a trailing portion that is non-circular along at least a portion of its periphery in top view;

the leading portion housing a control system for directing movement of the robotic cleaning device;

the trailing portion being linked to a surface contact element, and having a widest side-to-side width which is equal to or less than the widest side-to-side width of the leading portion.

2. The robotic surface treating device of claim 1, wherein the widest side-to-side width of the trailing portion is less than the widest side-to-side width of the leading portion.

3. The robotic surface treating device of claim 2, wherein the device is a cleaning device and the surface treating contact element is a cleaning cloth.

4. The robotic surface treating device of claim 3, wherein the cleaning cloth is linked to a dust ruffle.

5. The robotic surface treating device of claim 3, wherein the cleaning cloth is made of an electrostatic material.

6. The robotic surface treating device of claim 5, wherein the cleaning cloth is linked to an electrostatic skirt in the form of a dust ruffle, both the skirt and the dust sheet being positioned so as to contact a surface being treated by the device when the device is moved over the surface.

7. The robotic surface treating device of claim 6, wherein the ruffle also extends radially outward along the rear and sides of the trailing portion.

8. The robotic surface treating device of claim 7, wherein the ruffle is impregnated with at least one of a fragrance, an insecticide, a polish, or a cleaning fluid.

9. The robotic surface treating device of claim 2, wherein the trailing portion is constructed to provide pressure on the dust sheet to assist its contact with a surface to be treated by the device.

10. The robotic surface treating device of claim 2, wherein the device is selected from the group of vacuum cleaners, floor polishers, floor waxers, mowers and dispensers of agricultural chemicals.

11. The robotic surface treating device of claim 2, wherein the trailing portion is essentially rectangular in top view.

12. The robotic surface treating device of claim 2, further comprising a motor for causing movement of the device.

**13.** The robotic surface treating device of claim 1, wherein the cleaning cloth comprises a first section comprising a cleaning material and a second section comprising a treating material.

**14.** A disposable dust ruffle for use with a claim 5 device, the ruffle comprising:

an essentially cup-shaped portion made at least in part of an electrostatic material;

a fastener attached along an upper rim of the cup; and

a skirt made at least in part of an electrostatic material and extending radially outward and downward from the upper rim of the cup.

**15.** The ruffle of claim 12, wherein the fastener is an elastic band.

**16.** A method of treating a surface comprising moving a device of claim 1 over the surface.

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