

March 16, 1971

KIYOMI WADA

3,570,040

FLOOR AND GROUND CLEANER

Filed March 7, 1969

9 Sheets-Sheet 1

FIG. 1

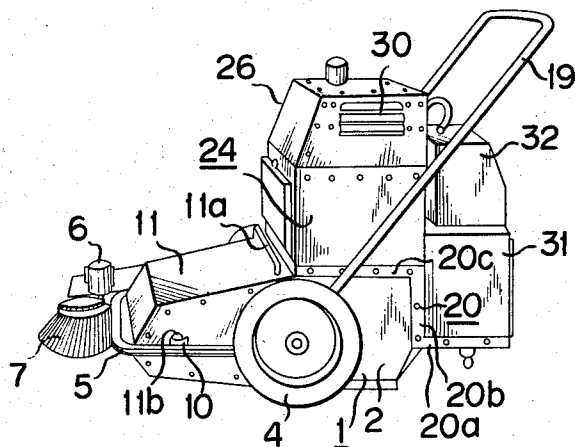
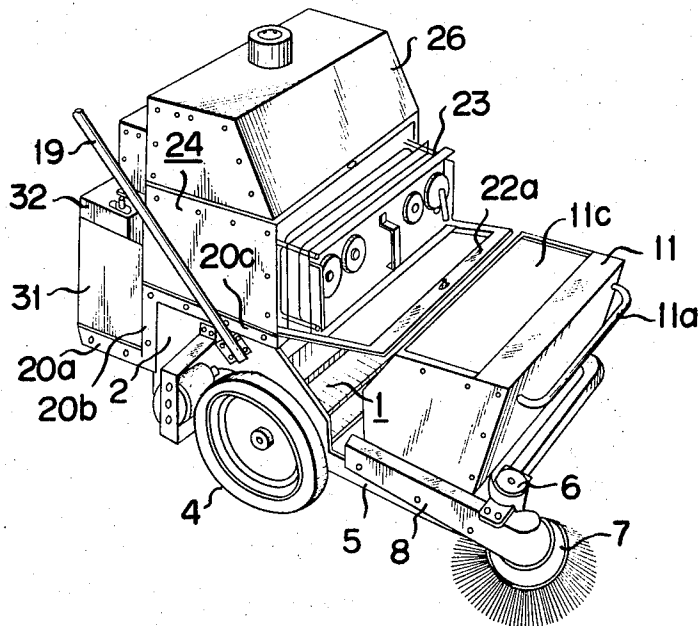


FIG. 2



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FIG. 3

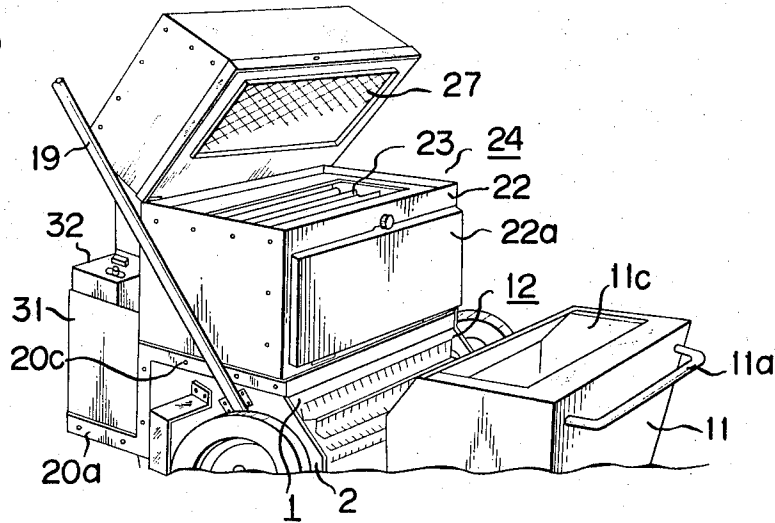
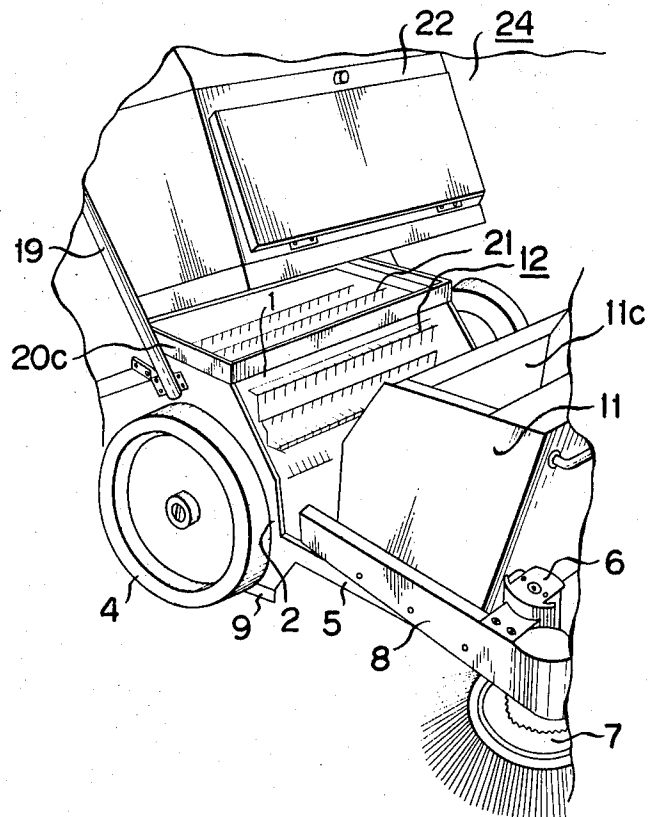


FIG. 4



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FIG. 5

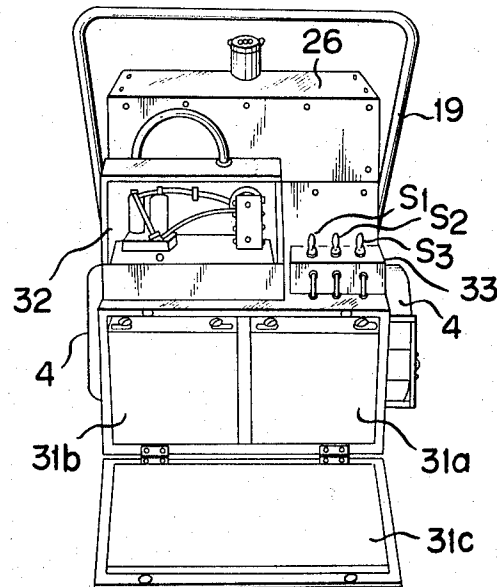
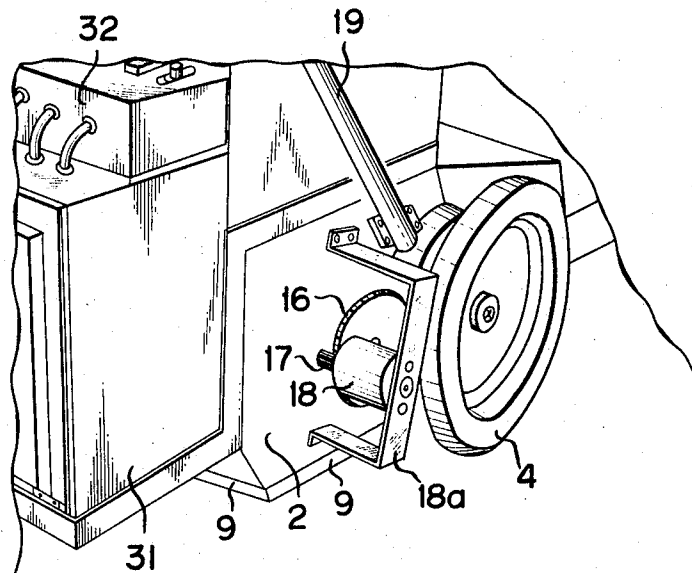


FIG. 6



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FIG. 7

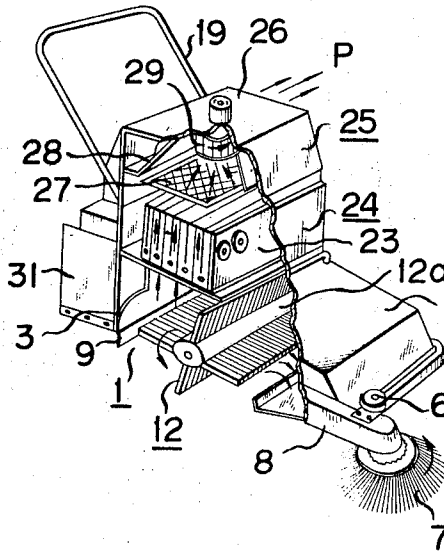


FIG. 8

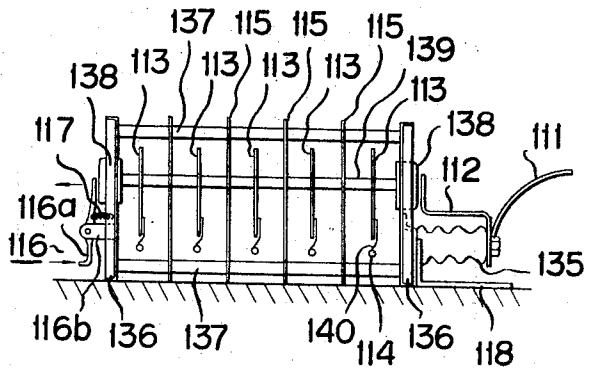
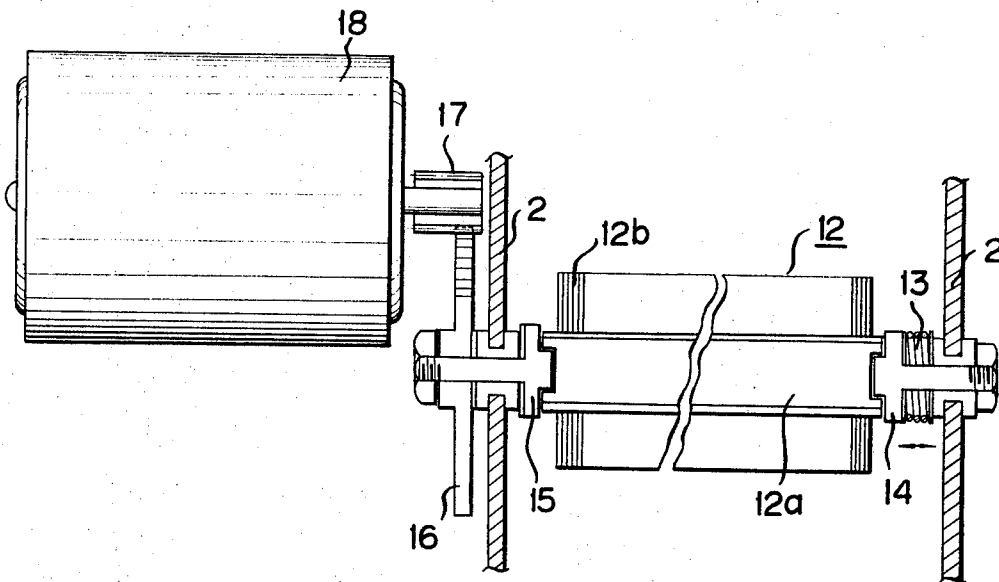


FIG. 9



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FIG. 10

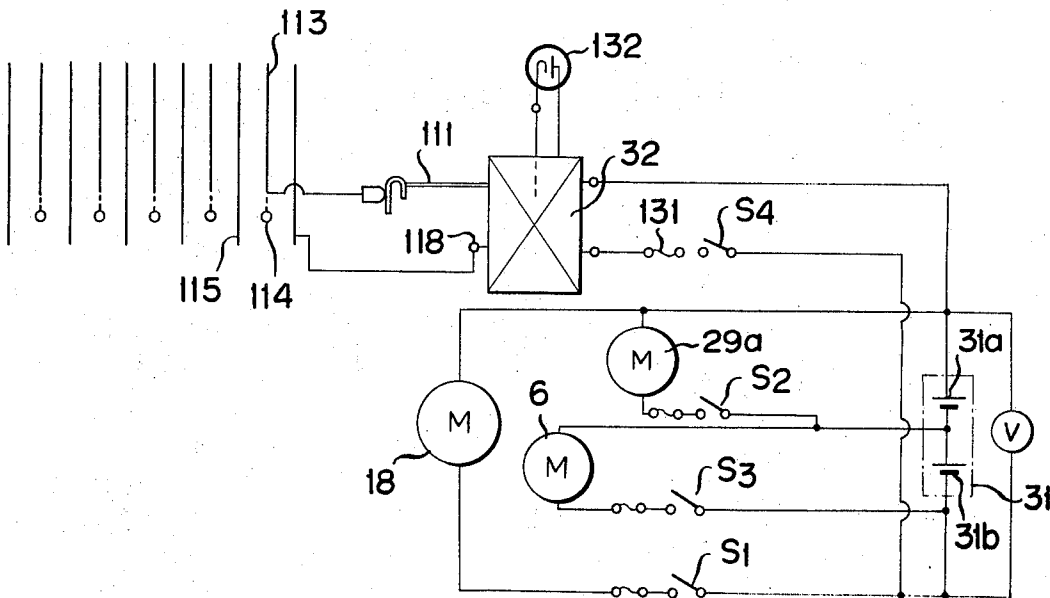
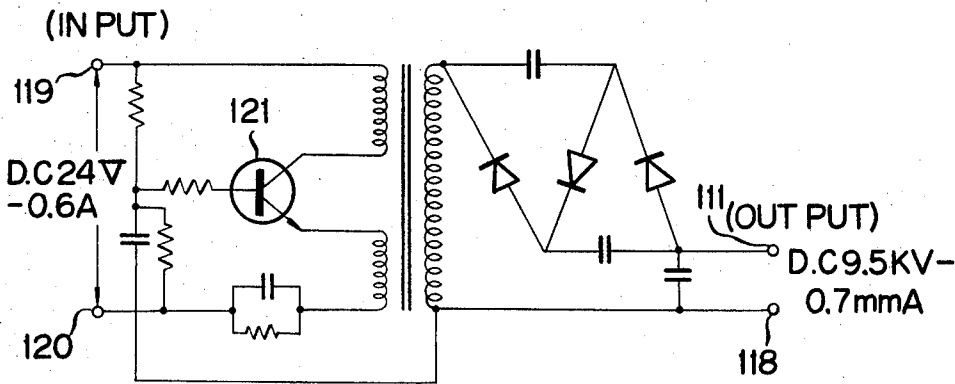


FIG. 11



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FIG. 12

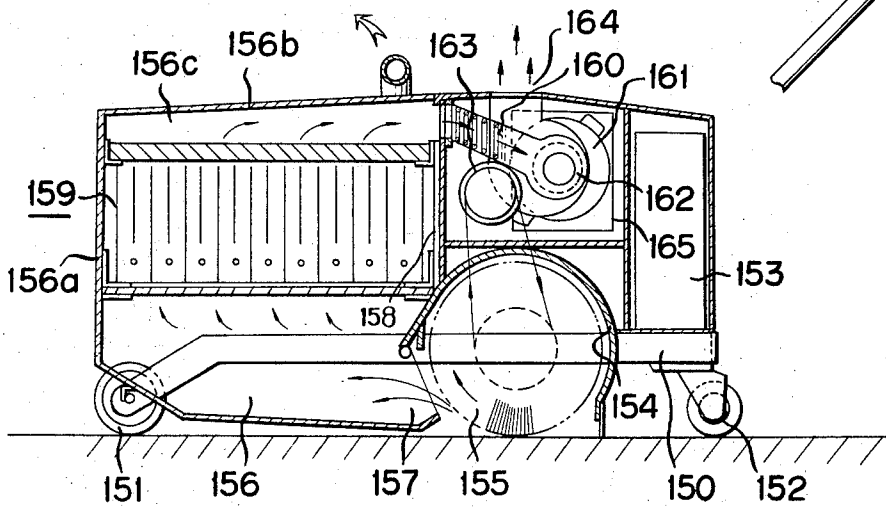
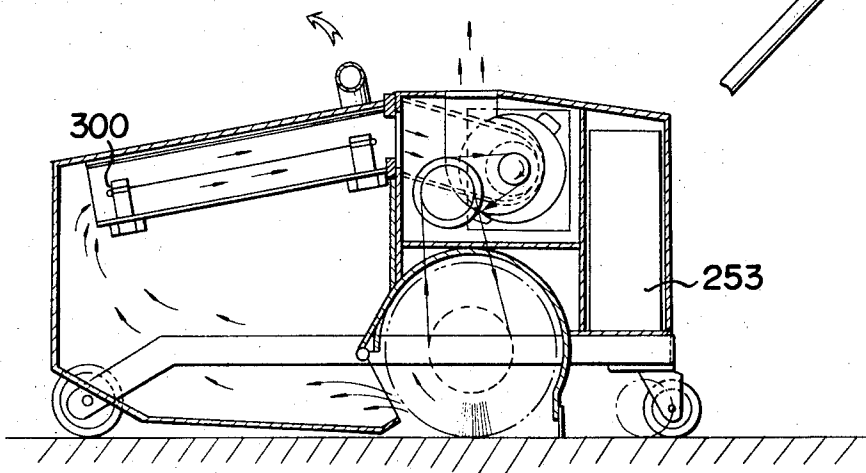


FIG. 13



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FIG. 14

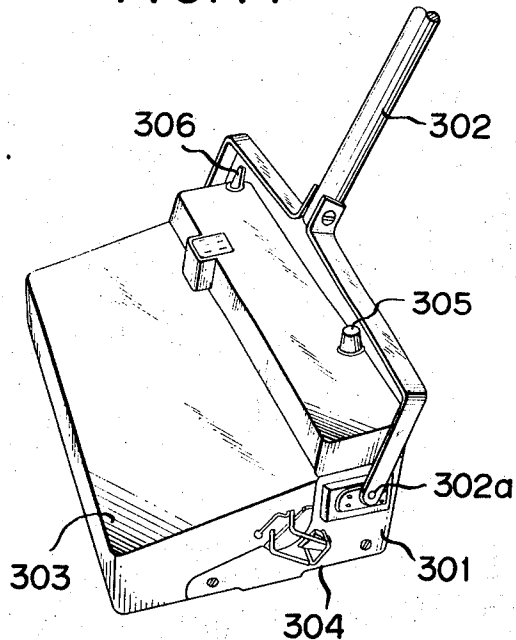


FIG. 15

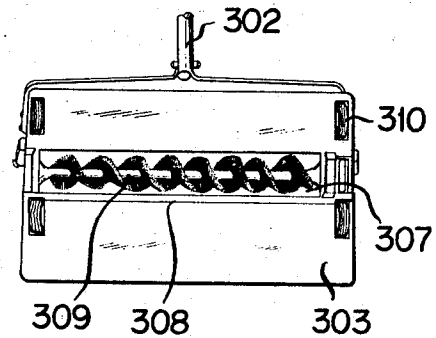
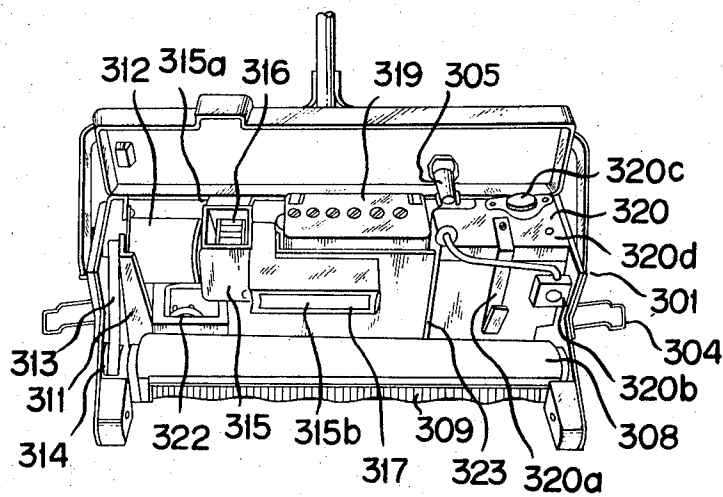


FIG. 16



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FIG. 17

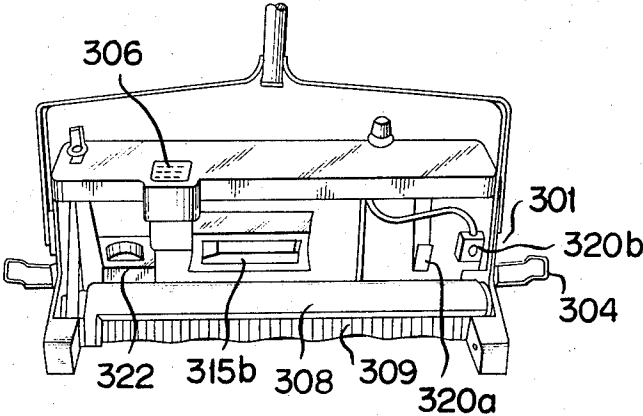
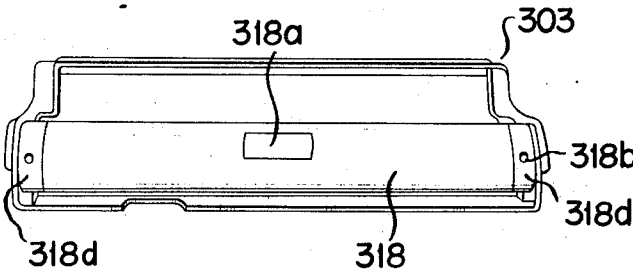


FIG. 18



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FIG. 19

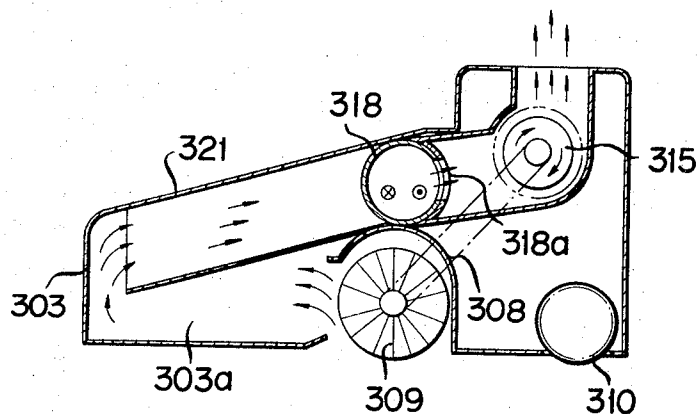
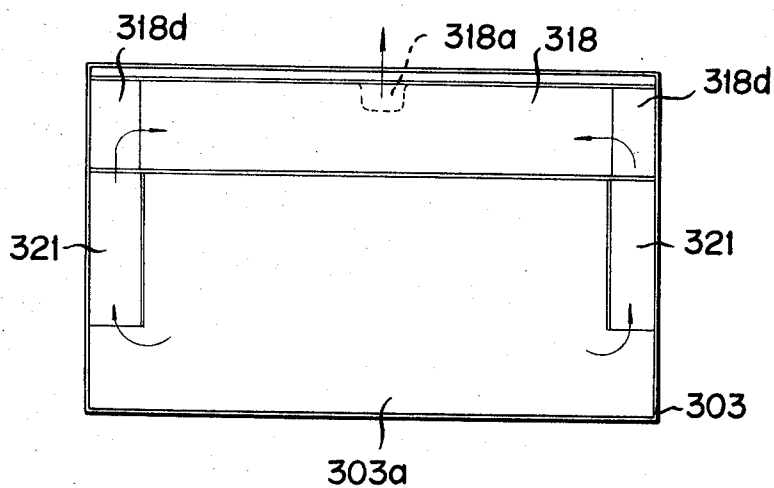


FIG. 20



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FLOOR AND GROUND CLEANER

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Claims priority, application Japan, Mar. 8, 1968,

43/15,063

Int. Cl. A47I 9/10, 11/202

U.S. Cl. 15—349

9 Claims

ABSTRACT OF THE DISCLOSURE

A novel and versatile cleaner is composed of a cleaner body movably supported on wheels, a rotating brush enclosed in a housing at the lower portion of the cleaner body and allowed to contact with the floor surface at least while the cleaner is operated, a dust box detachably mounted in the cleaner body for receiving dust stirred up from the floor by the brush operation, an air passage extending from the brush portion or the dust box to the outside of the cleaner body, an electric precipitator, or, an electrostatic dust collecting unit, detachably mounted in the air passage, an air blower to introduce air through said air passage, an electric motor for driving the rotating brush and the blower, a high voltage power source for supplying a high voltage to the electric precipitator, and an electric power source for supplying power to the high voltage source and to the electric motor.

BACKGROUND OF THE INVENTION

This invention relates to cleaning devices, and more particularly to a novel type of floor and ground cleaner wherein a rotating brush driven by an electric motor sweeps the dust on the floor into a dust box, and wherein minute particles of the dust, floating in the brush area, are sent by a blower into an electric precipitator energized from a power source through a high voltage power unit so that clean air free from minute dust particles is exhausted to the outside of the cleaner.

A type of room cleaner or vacuum cleaner which comprises a rotating brush, a dust box provided in front of the rotating brush, the dust box receiving the dust swept up by the rotating brush, an air passage extending from the brush area to the outside of the cleaner, a cloth-bag located in the passage for collecting dust and acting as a filter, and a blower for sending air through the passage is known. However, such a cloth-bag type cleaner has the following drawbacks:

(1) The kind of mechanical filter used inevitably has a small size mesh which tends to be made ever smaller by the deposition of dust. As a result, a very large blower capacity is required for causing air to flow through this kind of filter, and the static pressure-loss caused by the filter often reaches several tens of mm. Hg.

(2) Comparatively larger particles of the dust are also transported into the dust collecting bag due to the force of the large quantity of blown air, whereby the bag adapted to receive merely fine dust is quickly clogged, thereby requiring frequent removal of such dust and impairing the operational efficiency of the cleaner.

(3) The size required for the blower becomes large.

(4) It is difficult to remove fine dust from the air by means of a mechanical filter because of technical and economical reasons, and there is a high probability that the operator will inhale dust particles of from 100 to 200 microns, which probability is not desirable from the point of view of hygiene.

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SUMMARY OF THE INVENTION

Therefore, the primary object of the present invention is to eliminate the above described drawbacks of the conventional device by the utilization of an electric precipitator.

Another object of this invention is to provide a floor and ground cleaner employing an electric precipitator wherein the dust collecting elements are composed of parallel electrode plates and discharge wires disposed therebetween, whereby comparatively larger dust particles are received in an electric precipitator of comparatively larger size and only fine dusts are collected in the electric precipitator.

Still another object of this invention is to provide an improved floor and ground cleaner wherein a short-circuiting switch, operatively interlinked with the opening door of the dust collecting section, is provided for short-circuiting the dust collecting electrode plates and the discharge wires, whereby safety for the operator is afforded at the time the dust collecting section is opened.

Still another object of this invention is to provide an improved type of cleaner wherein a coarse filter is interposed between the brush housing and the electric precipitator for preventing intrusion of foreign matter such as metal wire.

A further object of this invention is to provide a novel type of cleaner wherein an auxiliary rotating brush is disposed at the front corner of the cleaner for transferring dust into the cleaning range of the principal cleaning brush.

An additional object of this invention is to provide a modified form of the cleaner wherein a plurality of tubular electrodes are utilized in the electric precipitator, whereby the size of the cleaner is substantially decreased.

These and other objects of the present invention are achieved by a novel type of floor and ground cleaner comprising: a cleaner body having wheels, a rotating brush enclosed in the lower portion of the cleaner body and contactable with the floor surface at least while the cleaner operates, a dust collecting box detachably encased in the cleaner body for receiving dust raised from the floor by the rotating brush, an air passage extending from the brush portion or the dust collecting box to the outside of the cleaner body, an electric precipitator detachably mounted within the air passage, an air blower for sending air through the air passage, an electric motor for driving the rotating brush and the blower, a high voltage power unit for supplying a high voltage to the electrostatic dust collector, and an electric power source for supplying power to the high voltage unit and the electric motor.

The nature, principles, details, and utility of the invention will be more clearly apparent from the following detailed description with respect to preferred embodiments of the invention when read in conjunction with the accompanying drawings, in which like parts are designated by like reference numerals and characters.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings:

FIG. 1 is a perspective view of an embodiment of the present invention;

FIGS. 2 through 4, inclusive, are perspective views showing the disposition of the electric precipitator and the dust collecting box in the device of FIG. 1;

FIG. 5 is a rear side perspective view showing the battery section, high voltage unit, and control box of the same device;

FIG. 6 is a fragmentary perspective view showing the mounting arrangement of the brush rotating electric motor employed in this cleaner;

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FIG. 7 is a perspective view, with parts cut away, of the same embodiment of the invention showing the internal construction;

FIG. 8 is a front view of an electrostatic dust collecting element which is utilized in this example;

FIG. 9 is a view showing the mounting relations of the rotating brush;

FIG. 10 is an electric circuit diagram showing an example of the electrical system of the cleaner;

FIG. 11 shows an example of a circuit diagram for the high voltage power supply employed in the embodiment of this invention;

FIGS. 12 and 13 are longitudinal cross-sectional views respectively illustrating further embodiments of this invention;

FIG. 14 is a perspective view of still another embodiment of this invention of smaller size;

FIG. 15 is a bottom view of the example of FIG. 14;

FIGS. 16 and 17 are perspective views indicating the internal construction of this embodiment with the dust collecting box removed;

FIG. 18 is a perspective view showing the rear side of the dust collecting box utilized in this embodiment;

FIG. 19 is a side elevation, in vertical section, of the same example; and

FIG. 20 is a schematic plan view of the dust box and the electric precipitator.

DETAILED DESCRIPTION

Referring to FIGS. 1 through 9 showing an embodiment of this invention, it is apparent particularly from FIG. 7 that a housing 1 of the cleaner consists of side walls 2, 2 and a rear wall 3 so that the housing 1 is thereby formed into a channel shape. Laterally outwardly of the side walls 2, 2, a pair of wheels 4, 4 are provided, and together with another freely swiveling auxiliary wheel, not shown, the housing 1 is supported above from the floor or ground. Downwardly from both side edges of the channel shaped structure, resilient belts 9 are suspended so that the gaps between the structure and the floor are thereby blocked.

An arm 5 bent into a U-shape extends forwardly from the housing 1, and both ends thereof are fixed to the side walls 22. At one corner of the U-shaped arm 5, a circular brush 7, rotatable around a vertical axis, is mounted on the arm 5 via a supporting member 8 and is driven by a motor 6. With this circular brush 7, dust deposited on cornered portions of the floor is brought into the cleaning range of the cleaner. On both sides of the arm 5, seats 10, 10 having semicircular concavities (one of which is shown in FIG. 1) are provided, and shafts 11b, 11b for a dust collecting box 11 projecting from the sides thereof are placed on the seats 10, 10. The dust collecting box 11 has a handle on its upper surface, and when this handle 11a is pulled forwardly, the box 11 is rotated from the condition of FIG. 1 to that of FIG. 3. The box 11 can then be removed from the cleaner with the opening 11c directed upward. Thus the dust inside the dust collecting box 11 may be transported to any desired place and discharged.

In reference to FIG. 9, a rotating brush 12 is provided inside of the housing 1 and between the side walls 2, 2 thereof. The brush 12 has soft hair implanted radially around the periphery of a cylindrical core 12a which has a groove on each end. Each groove engages with a projection formed on each opposing end of members 14, 15 rotatably mounted through the side walls 2, 2. With this arrangement, the brush 12 is supported between the rotatable members 14, 15 and driven through a wheel 16 fixed to the member 15 and a pinion 17 from an electric motor. The motor 18 has a capacity ranging from several tens to several hundreds of watts, and it is mounted on a bracket 18a fixed to the side wall 2, as for example by bolts, as best seen in FIGS. 6 and 9.

In the operation of the cleaner, the dust on the floor

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is swept into the dust collecting box 11 by the forward rotation of the brush 12 which is mounted in a direction parallel to the floor surface and perpendicular to the traveling direction of the cleaner. Numeral 19 designates a handle of the cleaner, both ends of which are secured to the side walls 2, 2; it is by means of the handle 19 that the cleaner is pushed around the cleaning area of the room and ground.

Although the capacity of the electric motor 18 has been described as having a range of tens to several hundreds of watts, about 48 to 60 watts is enough for a nylon hair brush of about 250 mm. dia. and 380 mm. length. The brush housing 1 is reinforced by a frame 20 consisting of lower horizontal members 20a, and vertical members 20b, upper horizontal members 20c. The housing 1 is also provided with an air passage, as described later, which runs through the portion of the housing 1 above the brush 12 to the outside of the housing 1.

At the portion defined by the rectangular frame formed by the upper horizontal members 20c, an air filter 21 of extremely coarse mesh is provided, as indicated in FIG. 4, for preventing intrusion of larger particles into the electrostatic dust collector section and for straightening the direction of the air flow. This air filter 21 has no dust collecting effect and may be made of any rough-mesh material such as wire lath framed, for instance, by aluminum strips.

Above the air filter 21, a casing 22 which has openings on the upper and lower ends and also a door 22a on the front side thereof, is provided for encasing the electric precipitator 24. The unit 24 includes a plurality of dust collecting elements 23 defined by parallel planar electrodes. Above the casing 22, there is provided a blower unit 25 for sending the dust-rich air through the electrostatic dust collecting unit 24 through the lower and upper openings of the casing 22. The blower unit 25 consists of an outer casing 26, a filter 27 placed afterward of the electric dust collector 24 and at the entrance of the casing 26 for further straightening the air passed through the dust collector unit 24, and through an air guide 28, an electric blower 29, and an outlet port 30 provided on the sidewall of the casing 26. The capacity of the blower 29 is preferably within the range from 1.5 to 2.5 m.³/min.

On one hand, a battery box 31 is provided on the lower horizontal member 20a of the reinforcing frame 20, as best seen in FIGS. 1 and 5, and, by way of opening the door 31c, the batteries 31a, 31b are detachably placed in the battery box 31. Above the battery box 31, a high voltage power unit 32 and a control box 33 are fixedly mounted side by side by means of, for instance, machine screws. As described below, a control circuit and a plurality of switches are disposed within the control box.

Referring to FIG. 8, there is illustrated an electrostatic dust collecting element 23 having parallel planar electrodes, a plurality of which are formed into the electric precipitator 24. A high voltage of about 8 to 10 kv. is supplied by a cable 111 from the high voltage power unit 32 to a porcelain insulator 135 which is mounted on one of metal plates 136, 136 fixed oppositely by means of two parallel bars 137, 137 also of electrically conductive material. On the free end of the insulator 135, an end of the cable 111 is connected with an end of a high voltage lead 112. The other end of the lead 112 is connected to a projecting portion of an electrically conductive bar 139 supported horizontally between two insulating plates 138, 138 which are attached to the aforementioned metallic plates 136, 136, respectively. The electrically conductive bar 139 supports five high voltage electrode plates 113 in a spaced apart relationship, and each of the electrode plates 113 is provided with a conductive spring 140 at the lower end thereof. Electric discharge wires 114 of 0.25 to 0.5 mm. dia., and made of tungsten, are suspended from the conductive springs 140, so that the wires 114 run in a direction perpendicular to the plane of the drawing. On the right-hand side surface of the

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metallic plate 136, another terminal 118 is provided. Furthermore, on the two electrically conductive bars 137, 137, running horizontally, a plurality of dust collecting electrode plates 115 are secured in such a manner that the above described electrode plates 113 and the attached tungsten wires are interposed respectively between the dust collecting electrode plates 115, and these plates 115 are connected through the bars 137, 137 and a metal plate 136 to the terminal 118.

The other end of the electrically conductive bar 139 projecting from the insulating plate 138 at the left-hand side of the assembly is provided with a contact of an actuator 116a of a short circuit switch 116. The actuator 116a is pivotally mounted on a bracket 116b secured to the lower portion of the metallic plate 136, and whenever the door 22a of FIG. 2 is opened, the actuator 116a closes the contact at the end of the conductive bar 139 under the tension of a spring 117 inserted between the actuator 116a and the metallic plate 136. When the door 22a of FIG. 2 is closed, the actuator 116a is moved in the arrowed direction, and the short-circuit switch 116 is opened.

With this arrangement, when a high tension voltage of about 8 to 10 kv. is supplied through the cable 111 across the terminals 112 and 118, as described hereinafter, the high tension voltage is conducted from the high tension terminal 112 through the conductive bar 139, high tension electrode plates 113, conductive springs 140, to the tungsten discharge wires 114. The dust collecting electrode plates 115 are connected through the metallic plate 136 and the conductive bars 137 to the opposite terminal 118.

In the operation of the cleaner, when air including dust is sent from the lower opening upward through the plurality of discharge wires and the dust collecting electrode plates, across which a high voltage is applied, the dust particles are changed with positive or negative potential depending on the polarity of the high voltage, and dust particles of more than 0.1-micron size are removed almost completely from the air.

During this time, if the door 22a is opened, the actuator 116a of the short circuit switch 116 closes the contact under the tension of the spring 117, and the high voltage is removed from the electrode plates 113 and the wires 114. When the door 22a is closed, the short circuit switch 116 opens its contact, and the high voltage is again applied to the electrode plates 113 and the wires 114.

Although in this example a plurality of parallel electrode plates are employed in a single stage, it is possible to use also double stages of similar construction, or tubular type electrodes as in a Cottrell dust collector, depending on the density of the dust in the air, instead of the single stage construction. The Cottrell type unit is particularly advantageous for a smaller size cleaner.

Experiments were carried out on an example wherein single stage parallel electrode plates of 5 electrode pairs were assembled in a 200 x 200 x 400 mm.³ space, whereupon it was found that the best results can be obtained when an electric power of several hundreds of μ A., at 9 to 10 kv. is supplied to the electrodes. In these experiments, the air velocity at the portion of the electric dust cleaner was selected in a range of from 1 to 2 m./s.

Referring to FIG. 10, a control circuit highly suitable for controlling the cleaning device of the above described construction will now be described.

The output from two batteries 31a, 31b connected in series is partly supplied to the motor 18 of the rotating brush 12, and to the blower motor 29a and the motor 6 for the auxiliary circular brush 7, through switches S2 and S3, respectively. Furthermore, the high voltage power supply 32 is connected to the two series connected batteries 31a, 31b of about 12 to 24 v. through a switch S4 and a fuse 131, whereby the output from the high tension power unit 32 is supplied to the electric dust collector unit 24 through the above described terminal 111

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and the ground terminal 118. A neon bulb 132 is disposed at a suitable location exposed to the outside of the cleaner and nearest to the high voltage unit 32 so that it may indicate the existence of a high voltage electric field produced therefrom.

A circuit diagram of the high voltage power unit 32 is illustrated in FIG. 11. The power unit 32 is in itself a DC-DC converter wherein a well known high frequency oscillation circuit consisting of a power transistor 121 is energized through the input terminals 119, 120 from the batteries 31a, 31b, and the high frequency output of about several tens of kc. is furnished to the primary winding of a flyback transformer. The output from the secondary winding of the flyback transformer is thereafter applied to a voltage multiplier circuit, as shown in FIG. 11, consisting of rectifiers and capacitors, and an output of about 8 to 10 kv. is obtained across the output terminals 111, 118.

The operation of this embodiment of the invention inclusive of the control circuit will now be described.

As is apparent from FIG. 10, when the operator of the cleaner closes the switch S4, the power from the batteries 31a, 31b is furnished through the switch S4 and the fuse 131 to the high voltage power unit 32 shown in FIG. 11, and a high voltage of about 8 to 10 kv. is generated across the terminals 111, 118 through the high frequency oscillating circuit, flyback transformer, and the voltage multiplier, thereby causing the neon lamp 132 to glow. Accordingly, whenever the door 22a of the electric dust collecting unit 24 is closed and the short circuit switch 116 is opened against the spring 117, the high voltage is applied partly across the discharge wires and the high tension electrodes, and partly across the dust collecting electrodes, whereby the electric dust collecting unit 24 is brought into the operating state.

Next, the switch S2 is closed to start the blower motor 29a. The operation of the blower 29 forces the air in the brush housing 1 to flow through a passage indicated in FIG. 4 and FIG. 7. The air passes through the coarse filter 21 and is thereby rectified into a laminar-flow stream which passes between the parallel electrodes 115 of the electric dust collecting unit 24, through an aft-filter for again rectifying the stream, and through an air guide 28 to the blower 29 to be vented to the atmosphere through the outlet port 30 on the side of the blower unit. Thus, the fine particles of the dust carried in the air are caught on the dust collecting electrodes of the electric dust collector 24, and clean air is exhausted from the outlet port 30.

Upon closing of the switch S1, the motor 18 for the rotating brush is started, which in turn rotates the brush 12 through the pinion 17, gear wheel 16, and rotating member 15. If, with the cleaner in this condition, the operator pushes the cleaner forwardly by means of the handle 19, the dust deposited on the floor will be swept into the inlet 11c of the dust collecting box 11 under the action of the brush 12, which is being rotated in the arrowed direction shown in FIG. 7.

However, fine particles of the dust in this case are also wafted up throughout the housing 1 and sent through the coarse prefilter 21 to the electrostatic dust collector 24 by the blower 29. In the electrostatic dust collector 24, the particles are electrostatically charged under the high voltage applied across the discharge wires and the dust collecting electrodes 115, and the particles thus charged are shifted to the electrodes 115 and deposited thereon. As a result, the air sent upward through the aft-filter 27 and the blower 29 and exhausted from the outlet port 30 is substantially free of fine dust.

If it is desired to clean corners or floor parts closely adjacent to the walls of a room, the switch S3 is closed, and the motor 6 is started, so that the auxiliary brush 7 provided in front of the cleaner is brought into operation. In this way, the dust in such floor parts is swept out

into the area where the dust can be reached and swept by the rotating brush 12.

Upon completion of cleaning, the door 22a of the case 22 of the electric dust collector 24 is opened, and the elements 23 are taken out of the case 22 to be water washed in a suitable place. When the dust collecting elements 23 are again inserted into the case 22, all of the electrical connections are automatically reconnected, and the original state of the cleaner is attained.

As is apparent from the above description, this embodiment of the invention can substantially eliminate the creation of an unhygienic environment as that accompanying the conventional cleaner in which a dust collecting bag-filter is utilized; and, by the use of the electrostatic dust collecting unit of minimum power consumption, the capacity of the blower can be substantially decreased. Furthermore, with the arrangement of this embodiment of the invention, the drawback of the conventional cleaner of requiring frequent change of the filter bag due to clogging can be substantially overcome, and the operational efficiency of the cleaner can be remarkably improved.

FIGS. 12 and 13 illustrate further embodiments of the invention wherein the height of the cleaner is made lower than that of the above described example. The cleaner illustrated in FIG. 13 is similar to that shown in FIG. 12 except that a tubular electrode is employed in the electrostatic dust collecting unit of the example shown in FIG. 13. Since the constructions of both of these examples are very similar to that described above, they will be described with reference mostly to FIG. 12.

At the front end of the reinforcing member 150, main wheels 151 are provided, and at the rear end thereof, a caster wheel 152 which can swivel freely is provided. Numeral 153 designates batteries. In a brush housing 154 formed into a substantially semi-circular configuration, a rotating brush 155 is accommodated as described in the previous embodiment in a manner such that the outer periphery of the brush 155 contacts the surface of the floor or ground to be cleaned. When the brush 155 rotates, the dust deposited on the floor is swept into a dust collecting chamber 156, which is located forwardly adjacent to the brush housing, through an opening 157. Between the front wall 156a of the dust collecting chamber 156 and a wall rising from the semi-circular casing 154, is encased an electrostatic dust collecting unit 159 of parallel electrode type, and the unit 159 is connected to the inlet of an electric blower 161 through a duct 160 extending from the space 156c inside of the top wall 156b to the blower chamber 165 at the upper portion of the housing. An electric motor 162 is directly connected to the blower 161, and the motor 162 at the same time drives the rotating brush 155 through a pulley 163 mounted on the other end of the shaft.

The cleaner of this example operates as follows.

When the rotating brush 155 is driven by the motor 162, the dust on the floor is swept into the dust collecting chamber 156 through an opening 157, and fine particles of the dust floating in the chamber 156 are guided into the dust collecting unit 159, to be filtered in the unit, and the air thus cleaned is drawn by the blower through the duct 160 to be blown out of the cleaner through the exhausting port 164.

The example shown in FIG. 13 employs, as described above, a plurality of tubular dust collecting electrodes 300 arranged in parallel to the direction of air flow in the dust collecting chamber, and, in each of the tubular dust collecting electrodes 300, a discharge wire is extended along the centerline of the electrode. The dust laden air passing from one end of the tubular electrode 300 to the other end thereof is cleaned within the electrodes 300. Accordingly, this type of electrode can provide a larger effective dust collecting area than that of the parallel electrode plate type and, hence, is suitable for use in a smaller type cleaner.

Another embodiment of this invention which can be

employed more easily in offices and like compartments, is illustrated in FIGS. 14 through 20. Although the construction of each of these examples is fundamentally equivalent to that shown in FIG. 13, an improvement is provided in that an elongated tubular electrode is disposed above the rotating brush, and parallel thereto, so that the width of the inoperative portion at the front of the cleaner is minimized, and difficulty in removing dust at the corners of a room can be eliminated without the provision of an auxiliary brush. In FIG. 14, there is illustrated a main cleaner body 301 provided with a handle 302 swingably attached to the main cleaner body by its bifurcated ends 302a. At the front part of the main body 301, there is provided a dust collecting box 303 which is detachably held in place by means of fasteners 304. On the upper surface of the cleaner, a fuse 305, a switch 306, and an exhaust port are exposed.

As shown in the bottom view of FIG. 15, the brush housing 307 at the central portion of the cleaner is defined by a semi-cylindrical casing 308 both ends of which are supported by the side walls of the main body. Inside of the housing 307, a brush 309 is mounted to rotate freely around its axis. At four locations inside of the peripheral walls of the main body, freely rotatable caster wheels 310 are provided. The rotatable brush 309 is disposed in parallel with the room floor and perpendicular to the direction of travel of the room cleaner. As is apparent from FIGS. 16 and 17, from which the dust collecting box 303 is removed for the purpose of clarification, the driving power for the brush 309 is transmitted from an electric motor 312 mounted on a wall 311 inside of the main body 301 through a belt 313 and a pulley 314. The electric motor 312, at the other side thereof, is coupled to the blower 316, so that the blower casing 315 is mounted on the motor casing, and the fan of the blower 316 is directly coupled to the motor shaft. When the dust collecting box 303 is mounted on the main body 301 by means of the fasteners 304, the outlet 315a of the blower is located just below and in abutment with the inside of the exhaust port, and the inlet 315b of the blower is coupled in an air tight manner with a central port 318a of the elongated tubular dust collecting electrode 318 through a gasket 317 as shown in FIG. 18. Numeral 322 designates a power unit consisting of a well known combination of a transformer and silicon rectifier which can act as a charger for the battery 319 and also as a compatible driving power source for the cleaner. With this unit 322 as the power supply means, the cleaner can be driven either from the battery or from an A.C. line of 100 to 117 v., for example.

At the upper part of the dust collecting box 303, which is shown inverted in FIG. 18, an elongated tubular electrode 318, made of aluminum, is disposed so that when the box 303 is fastened in position, the tubular electrode 318 comes above and is disposed in parallel with the brush 309. The tubular electrode 318 is forcibly inserted in the above described position between two insulated end members 318d, each of which has an air passage not shown in the drawing. Inside of the tubular electrode 318, a discharge wire (also not shown) is extended along the centerline of the electrode 318, and both ends of the wire are supported by respective terminals located at the center of the insulating members 318d. A lead 318b projecting from one of the insulating members 318d is connected to the corresponding terminal of the discharge wire. A battery 319 is encased in a compartment defined by the separating wall 323, and a high voltage power supply 320 (FIG. 16) is disposed adjacent the battery compartment. The high voltage power unit 320 comprises a transistor 320 attached to a cooling plate 320d, a high voltage porcelain insulator 320b mounted on the side wall of the main body 301, and an opposite terminal 320a. When the dust collecting box 303 is secured to the main body as shown in FIG. 14, the high voltage terminal 320b contacts the lead 318b connected with the discharge wire inside of the tubu-

lar electrode 318, while on the other hand, the opposite terminal 320a is brought into contact with the surface of the tubular electrode 318. Furthermore, for the purpose of guiding the dust-rich air inside of the dust collecting box 303, through air ports provided in the insulating members 318d at both ends of the tubular electrode 318, tubular ducts 321 are provided in parallel with the side walls of the main body as schematically indicated in FIGS. 19, 20. Each of the ducts 321 opens in the dust collecting chamber, and the other end thereof is air-tightly connected with each of the air ports (not shown) provided in the insulating members 318d.

In the operation of the embodiment of the invention described above, when the operator closes the switch 306, electric power is supplied through the battery 319 to the high voltage unit 320 having a transistor 320c as in the case of the above described example, and the output from the power unit 320 is furnished through the terminal 320b and lead 318b to the discharge wire extending along the centerline of the tubular electrode 318 and through the opposite terminal 320a to the surface of the tubular electrode 318. Thus, a high voltage is applied across the discharge wire and the tubular electrode 318. At the same time, the electric motor 312 is also started by the closure of the switch 306. Starting of the electric motor 312 causes the rotating brush 309 to operate, through the belt 313 and pulley 314, in the direction of the arrow of FIG. 19, and any dust on the floor is swept into the dust collecting chamber 303a. The fan 316 inside of the blower casing 315 and directly coupled to the motor 312 is also rotated, and the air is drawn upward from the dust collecting chamber 303a. The air from the chamber 303a then flows from the front ends of the ducts 321, 321, disposed in parallel with both side walls of the main body 301, as indicated by arrow marks in FIGS. 19 and 20, through the air ports (not shown) in the insulating members 318d, 318d, into the tubular electrode 318, and then along the length of the electrode 318 to the central port 318a. The air is further guided into the inlet port 315b of the blower and exhausted to the atmosphere from the outlet port exposed on the outside surface of the main body. If the cleaner in this condition is pushed forward by an operator pushing the handle 302, the dust on the floor is successively swept into the dust collecting chamber 303a by the rotating brush 309, and the air with the fine particles of the dust floating therein is transported into the tubular dust collecting electrode 318 by the air blower 316. Inside of the tubular electrode 318, the particles of the dust are charged by the high tension voltage applied across the discharge wire and the tubular electrode 318, and the particles thus charged are deposited on the inside surface of the electrode 318. Accordingly, the air exhausted from the outlet port on the surface of the cleaner is substantially free of fine dust.

When it is desired to remove dust deposited on the inside surface of the tubular electrode of the electric precipitator, the dust collecting box 303 is first removed from the main cleaner body 301 by releasing the fasteners 304, and the tubular electrode 318 is taken out of the box 303 against the resilient force exerted from both side walls for holding the electrode 318. The tubular electrode 318 thus removed is thereafter washed by pouring water into one of the air ports (not shown) in the insulating members 318d, and discharging it out of the other port in the other insulating members 318d. By this simple procedure, the dust deposited inside of the electrode can be removed together with the water. Of course, water may also be poured into the electrode through the central port 318a and discharged from the air ports at both insulating members 318d to obtain similar results.

Although it is stated in the above description that it is preferable to use one tubular electrode, wherein the air is introduced through the ports at both ends thereof and exhausted from the central port, for the purpose of improving the space-factor of the cleaner, it is also appar-

ent that various modifications are possible, such as to employ a plurality of similar electrodes in parallel or to guide the air in a different manner depending on the specific application requirements. Furthermore, if the tubular electrode is arranged in a position aligning with the rotating axis of the brush, the width of the forward inoperative portion of the cleaner can be substantially decreased.

According to the results of experiments, it has been made apparent that a rotating brush of about 50 mm. outside dia. and a tubular electrode of 50 mm. dia. and 400 mm. length can produce amply good results. An example of data for such construction of the cleaner is as follows:

- Total input power: 30 w.
- Motor capacity: 19 w.
- Battery capacity: 12 v., 6 AH
- Centrifugal fan diameter: 50 mm.
- Aluminum tubular electrode diameter: 50 mm.
- High voltage power source: 9.5 kv., 0.3 ma.

Furthermore, the hand-pushed type cleaner described above is merely illustrative, and the invention can be applied also to an engine driven type cleaner. Moreover, the cross-sectional configuration of the tubular electrode is not necessarily a circle, various other configurations also being utilizable.

I claim:

1. A floor and ground cleaner comprising: a cleaner body having wheels, a rotating brush enclosed in a lower portion of the cleaner body and contactable with a surface to be cleaned, a dust collecting box encased in the cleaner body for receiving dust raised from the surface by the rotating brush, said cleaner body defining an air passage extending from said lower portion of the body adjacent the brush to the outside of the cleaner body, an air blower mounted on said body for causing air to flow through the air passage, electrostatic dust collector means mounted within the air passage for removing minute dust particles which fail to precipitate into said dust collecting box, motive power means mounted on said body to drive the rotating brush and the blower, a high voltage power unit for supplying a high voltage to the electrostatic dust collector, and an electric power source connected to said high voltage power unit and motive power means for supplying power thereto.
2. A floor and ground cleaner as set forth in claim 1 wherein said electrostatic dust collector means comprises at least one dust collecting element including a tubular electrode, a discharge wire disposed within said tubular electrode, and means to support said discharge wire in said tubular electrode so that the wire is prevented from contacting said tubular electrode.
3. A floor and ground cleaner as set forth in claim 1 wherein said electrostatic dust collector means comprises at least one dust collecting element including a plurality of opposed parallel electrode plates, a discharge wire interposed between each adjacent pair of said parallel electrode plates, and means to support said discharge wires so that the wires are prevented from contacting said electrode plates.
4. A floor and ground cleaner as set forth in claim 1, further comprising an access door in communication with said air passage, and a safety switch mounted on said body for actuation by said door to short circuit the dust collecting electrode and the discharge wire whenever the door is opened.
5. A floor and ground cleaner as set forth in claim 1, further comprising a rotatable vertical shaft having a circular brush mounted thereon to sweep said surface at a front corner of the cleaner for moving surface dust at said front corner into the cleaning range of said rotating brush, means to support said circular brush to maintain the bottom surface thereof in contact with said surface, and means mounted on said cleaner body for rotating said circular brush.

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6. A floor and ground cleaner as set forth in claim 2 further comprising a filter disposed in said air passage between said rotating brush and said electrostatic dust collector means.

7. A floor and ground cleaner as set forth in claim 2 wherein said electrostatic dust collector means comprises a plurality of dust collecting elements, each including a tubular electrode having a discharge wire supported therein, said plurality of dust collecting elements being arranged in parallel within said air passage and being disposed in a direction parallel with the flow of air through said air passage, whereby dust-rich air guided into the spaces between said plurality of elements at one end thereof is cleaned inside of the elements, and the air thus thoroughly cleaned is exhausted from the other end of the elements.

8. A floor and ground cleaner as set forth in claim 2 wherein said tubular electrode is disposed substantially parallel with the rotating axis of said rotating brush.

9. A floor and ground cleaner as set forth in claim 8,

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wherein said tubular electrode has an opening at the central portion thereof, and further comprising insulating members attached to both ends of said tubular electrode, wherein both ends of said discharge wire are supported by said insulating members, whereby dust-rich air is guided through and from both ends of said tubular electrode and exhausted through said central opening of the tubular electrode.

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