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(54) **FLOOR MAINTENANCE MACHINE USING A SPIRAL, TUFTED, CYLINDRICAL BRUSH**

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(57) **ABSTRACT**

Leading and trailing cylindrical brushes (**14**) are moved in an operation direction to sweep and wet scrub a floor In differing aspects, the trailing cylindrical brush (**14**) is rotated at a greater rotational speed than the leading cylindrical brush (**14**) to enhance sweeping ability and preferably in the order of 1500 RPMs to enhance polishing. The brushes (**14**) include spiraled, equally circumferentially spaced rows (R) of a multiplicity of equally spaced tufts (**54**). The tufts (**54**) of an adjacent trailing row (R) are indexed laterally from a leading row (R) by an index distance (T) less than one half of the distance (I) of the tufts (54) in the rows (R).

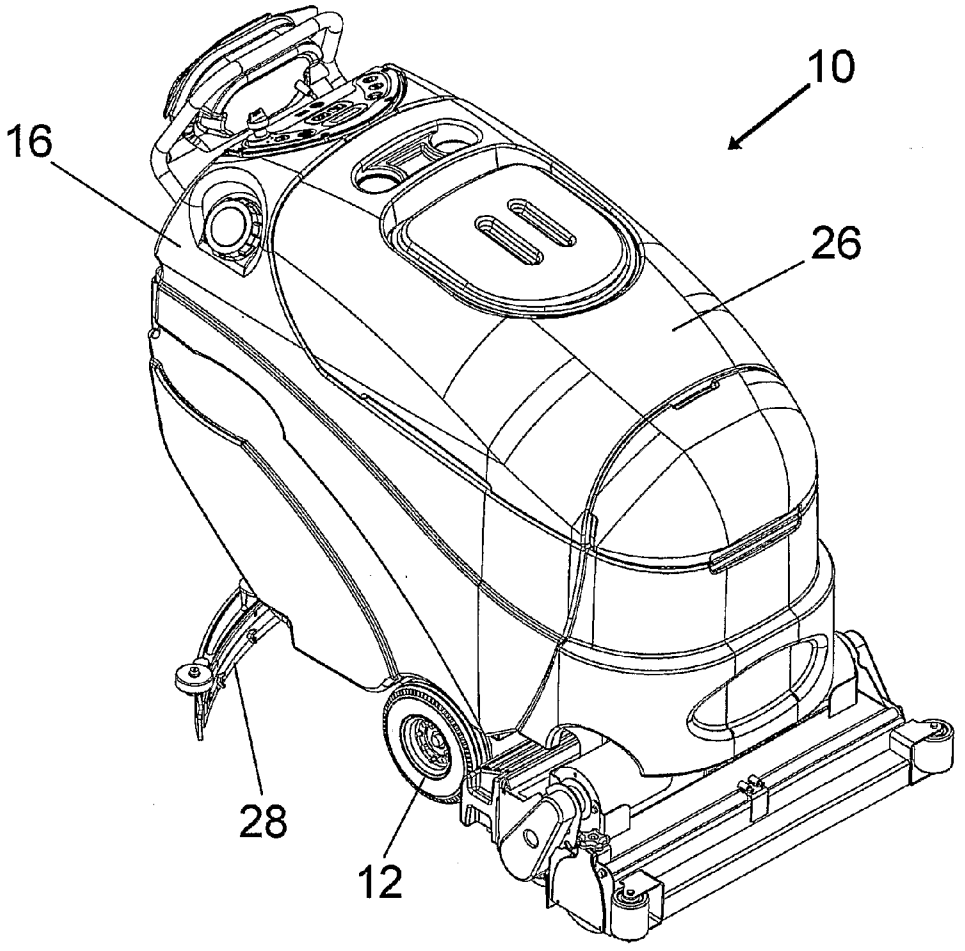
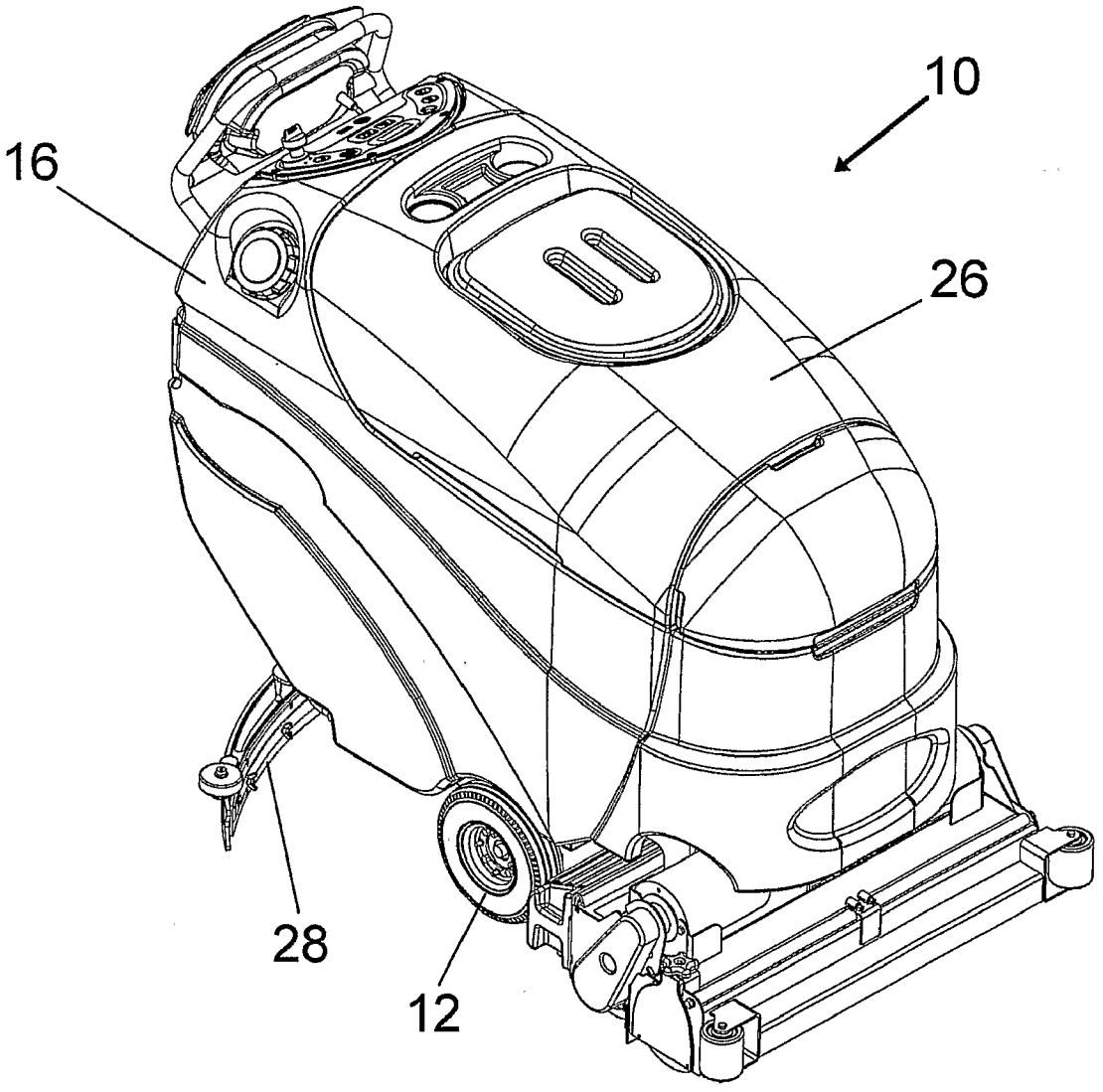


Figure 1



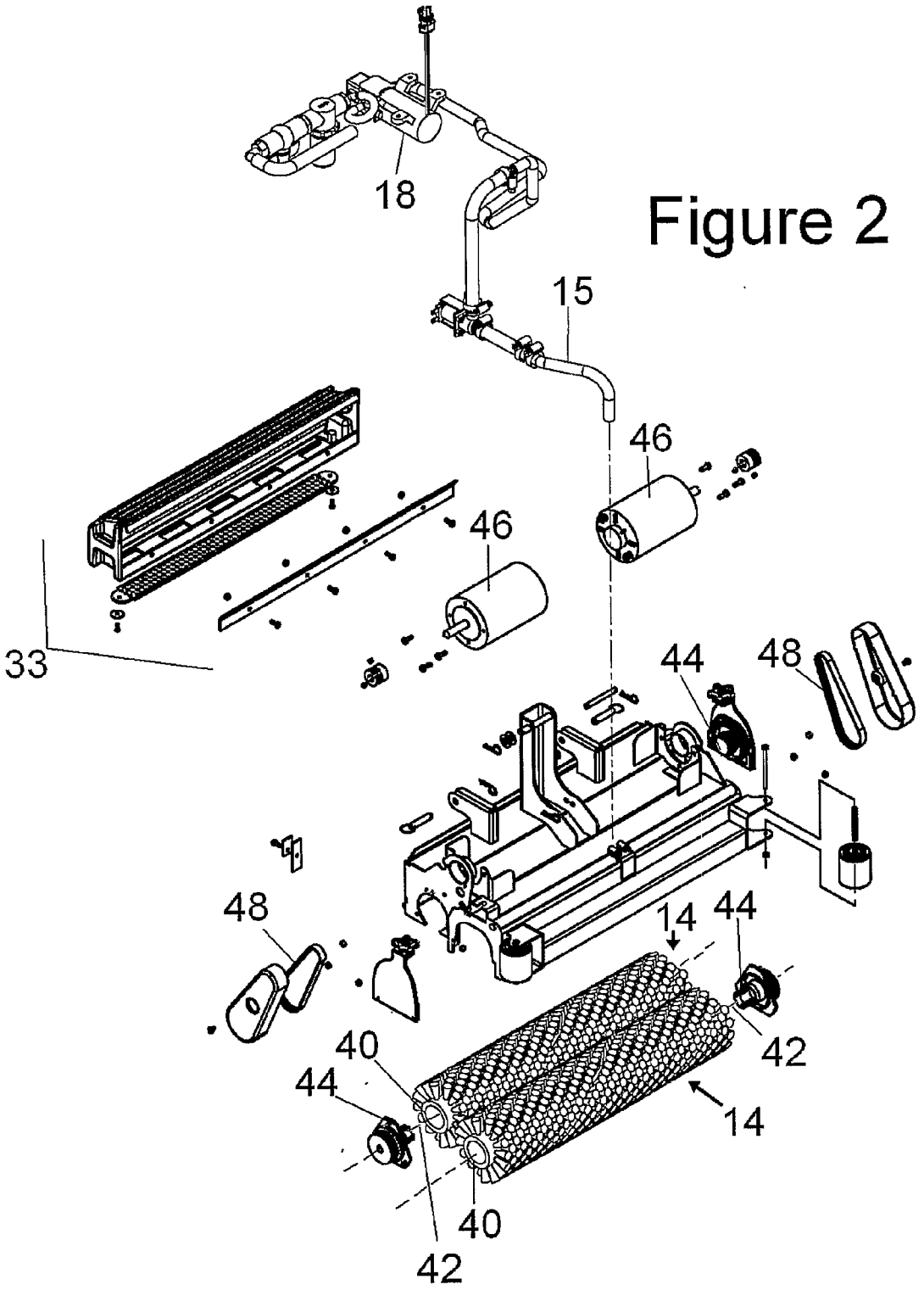


Figure 2

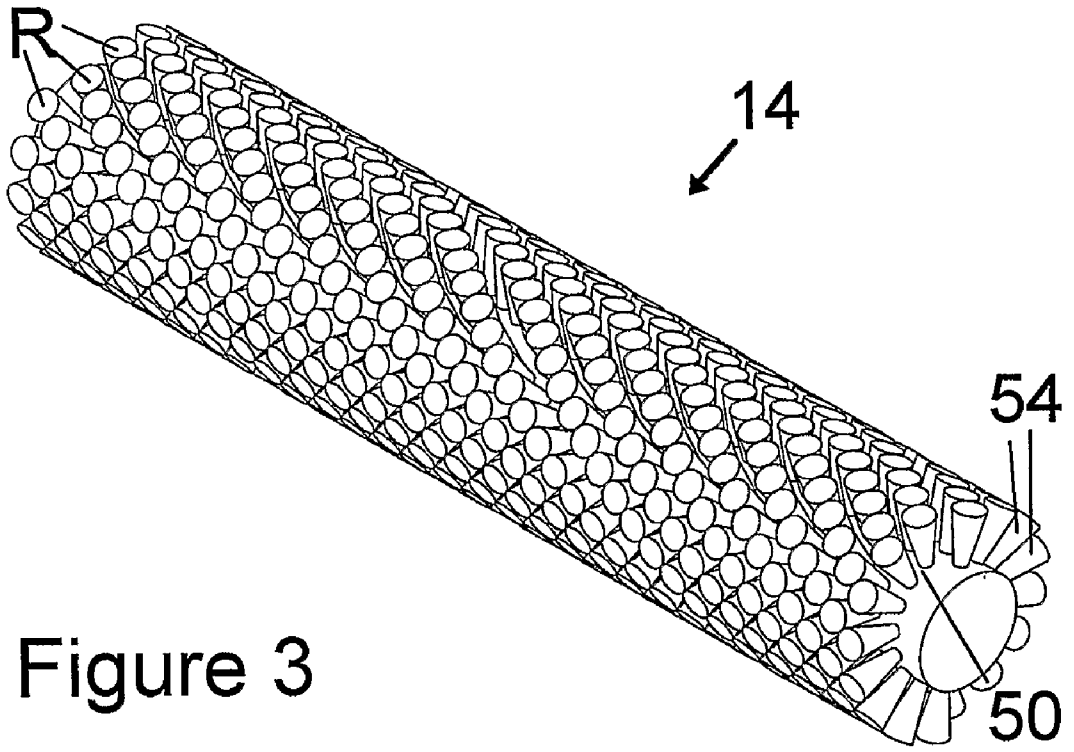


Figure 3

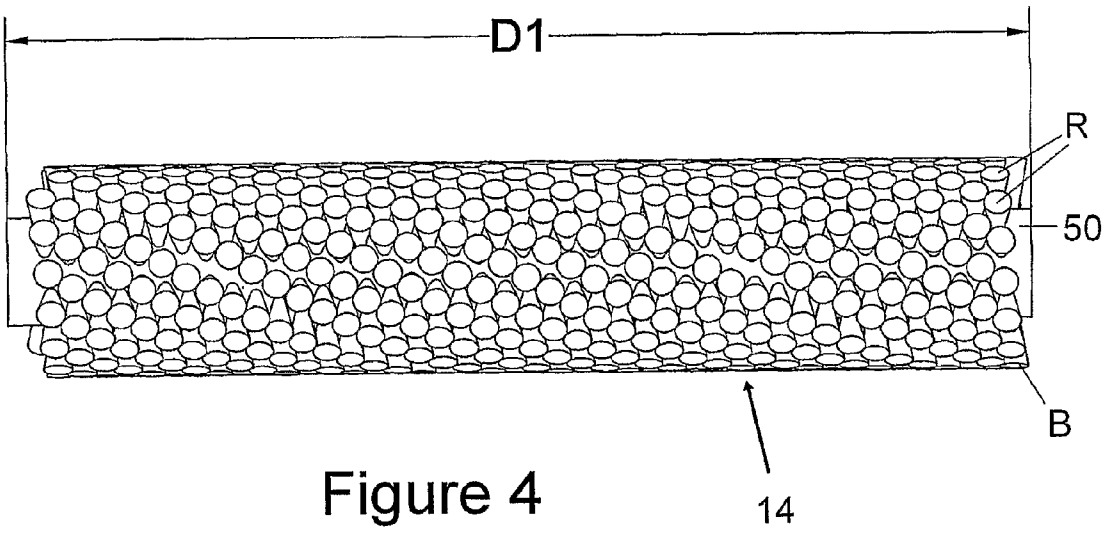
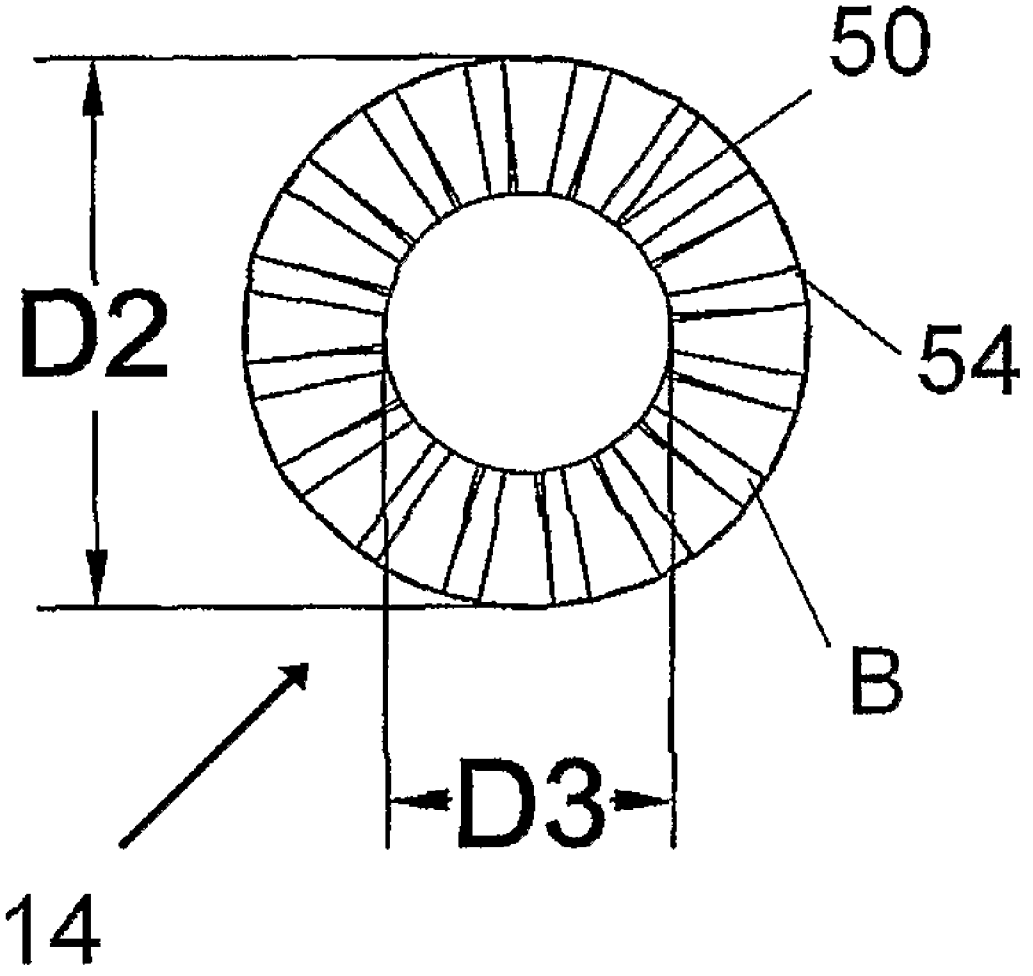


Figure 4

Figure 5



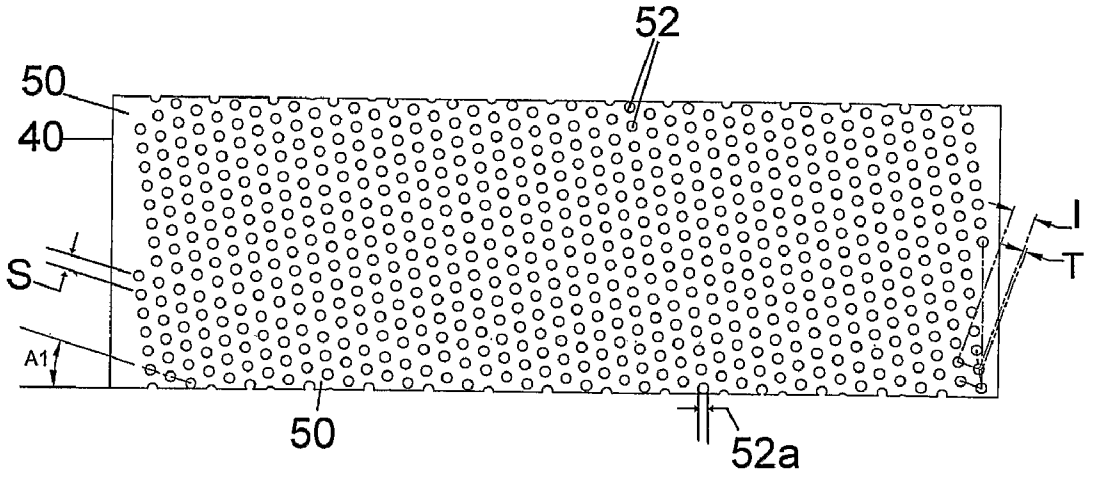


Figure 6

FLOOR MAINTENANCE MACHINE USING A SPIRAL, TUFTED, CYLINDRICAL BRUSH

BACKGROUND

[0001] The present invention generally relates to floor maintenance, particularly to both sweeping and wet scrubbing floors while removing only a negligible amount of floor finish, and specifically to novel cylindrical brushes which sweep and wet scrub without noticeably scratching or dulling the floor and to floor maintenance machines utilizing such novel brushes.

[0002] Floor maintenance on finished floors typically involves several separate operations. On floors such as resilient tile, polished concrete or colored epoxy, a floor finish is applied to the floor. The floor finish protects the floor surface and provides a glossy, clean appearance. Often, several coats of finish are applied to provide additional protection and longer wear.

[0003] Daily maintenance is performed by first pre-cleaning such as pre-sweeping or dust-mopping to remove debris from the floor. This is followed by scrubbing with an automatic scrubber. Automatic scrubbers dispense cleaning solution onto rotating agitator disc pads or brushes. The spent cleaning solution is then recovered with a vacuumized squeegee. Operation of automatic scrubbers is well known.

[0004] The scrubbing operations also remove a small amount of floor finish. This is due to the abrasive composition of the scrub pads/brushes. The rotation of the pads/brushes creates very small scratches in the finish which dull the appearance of the floor. In order to restore the floor finish back to a glossy appearance, the scrubbing operation is followed by high speed burnishing. Burnishing also removes a small amount of finish from the floor. Burnishing is a dry polishing process, and some of the dry, powdered floor finish becomes airborne and settles back onto the floor and surrounding surfaces. This often necessitates yet another operation to dust-mop the floor.

[0005] Restoration of finish requires periodic stripping and recoating of finish.

[0006] The majority of the cost of floor maintenance is not the equipment or the cleaning chemicals, but the labor to perform the above steps. If one or more steps in the process can be completely eliminated, the overall cleaning cost can be reduced significantly.

[0007] One conventional solution was to combine the pre-cleaning and scrubbing operations into one machine such as by using cylindrical scrub brushes instead of the more common disc style pads/brushes. The cylinder brushes sweep debris into a hopper while simultaneously performing the task of scrubbing. These cylinder brushes typically rotate at around 900 RPMs or less. The bristles on these cylinder brushes tend to be relatively stiff so that they can both sweep and scrub. Like disc brushes, the cylindrical scrubbers currently on the market remove a small amount of finish and create small scratches in the floor finish. As a result, they dull the appearance of the floor. So while cylindrical brush scrubbers currently available eliminate the need to pre-clean, they do not reduce or eliminate the need to burnish the floor to restore an acceptable level of gloss.

[0008] Attempts have been made to combine the scrubbing and burnishing operations into one machine so that they can be performed simultaneously such as disclosed in U.S. Pat. No. 6,023,813. Such machines still require pre-cleaning, do not address the removal of finish by the abrasive scrub pads, and may still require post-mopping to remove powdered floor finish residue. Further, such dual function machines are expensive and cumbersome to operate.

[0009] Thus, the present invention addresses a need in floor maintenance to reduce or eliminate steps in the daily cleaning of finished floors.

SUMMARY

[0010] The present invention solves several of the problems involved in daily floor maintenance by providing a machine that sweeps and wet scrubs while removing only a negligible amount of floor finish, and which does not noticeably scratch or dull the floor. This invention thus eliminates the need for pre-sweeping, frequent burnishing, and post-mopping. Additionally, because far less finish is removed, the frequency of stripping and recoating the floor is greatly reduced.

[0011] In a first aspect, the present invention relates to a brush and a floor maintenance machine utilizing such a brush. A multiplicity of rows of a multiplicity of tufts of bristles are equally circumferentially spaced on the cylindrical outer surface of a cylindrical core, are arranged at an acute angle to the rotational axis to create a spiral, and repeat in at least one identical row pattern upon the cylindrical outer surface. Tufts of an adjacent trailing row are indexed laterally from a leading row by an index distance less than one half of the equal spacing of the tufts in each of the multiplicity of rows.

[0012] In a further aspect of the present invention, counter rotating leading and trailing cylindrical brushes move in an operation direction with their rotational axes being spaced and parallel to each other and to the floor. The rotational speed of the trailing cylindrical brush is greater than that of the leading brush to enhance sweeping performance. In most preferred forms, the leading and trailing cylindrical brushes are of identical construction and include tufts of bristles arranged in a multiplicity of rows arranged at an acute angle to the rotational axis of the brush.

[0013] In still a further aspect of the present invention, a cylindrical brush moving in an operation direction parallel to the floor is rotated about a rotational axis at a rotational speed in the order of 1200 to 1800 RPMs to enhance polishing benefit. In most preferred forms, the brush includes tufts of bristles arranged in a multiplicity of rows arranged at an acute angle to the rotational axis of the brush.

[0014] The present invention will become clearer in light of the following detailed description of an illustrative embodiment of this invention described in connection with the drawings.

DESCRIPTION OF THE DRAWINGS

[0015] The illustrative embodiment may best be described by reference to the accompanying drawings where:

[0016] FIG. **1** shows a perspective view of a floor maintenance machine according to the preferred teachings of the present invention.

[0017] FIG. **2** shows an exploded perspective view of portions of a floor maintenance machine of FIG. **1**.

[0018] FIG. **3** shows a perspective view of a cylindrical brush utilized in the floor maintenance machine of FIG. **1**.

[0019] FIG. **4** shows a front elevation view of the cylindrical brush of FIG. **3**.

[0020] FIG. **5** shows an end elevation view of the cylindrical brush of FIG. **3**.

[0021] FIG. **6** shows a diagrammatic view of the outer surface of the cylindrical brush core of FIG. **3** with the tufts of bristles removed and with the outer surface unwrapped.

[0022] All figures are drawn for ease of explanation of the basic teachings of the present invention only; the extensions of the figures with respect to number, position, relationship, and dimensions of the parts to form the preferred embodiment will be explained or will be within the skill of the art after the following description has been read and understood. Further, the exact dimensions and dimensional proportions to conform to specific force, weight, strength, and similar requirements will likewise be within the skill of the art after the following description has been read and understood.

[0023] Where used in the various figures of the drawings, the same numerals designate the same or similar parts. Furthermore, when the terms "top", "bottom", "first", "second", "front", "back", "height", "width", "length", "end", "side", "trailing", "leading", "horizontal", "vertical", "axial", "radial", "longitudinal", "lateral", and similar terms are used herein, it should be understood that these terms have reference only to the structure shown in the drawings as it would appear to a person viewing the drawings and are utilized only to facilitate describing the illustrative embodiment.

DESCRIPTION

[0024] A floor surface maintenance machine such as a floor surface sweeping and wet scrubbing machine according to the preferred teachings of the present invention is diagrammatically shown in FIG. **1** and generally designated **10**. In the preferred form shown, machine **10** is movably supported by three or more wheels, casters or the like **12** upon the surface to be cleaned, with one or more of the wheels, casters or the like **12** being driven if desired. The operator can either walk behind or ride upon machine **10** as desired. Machine **10** includes suitable elements for maintaining the floor surface such as first and second rotatable cylindrical brushes **14** mounted to machine **10** for rotation about spaced parallel rotational axes **42** parallel to the floor as diagrammatically shown. In the most preferred form shown, brushes **14** are of identical construction. A cleaning solution such as but not limited to water and water-based solutions (which can be premixed or which could be separately provided and mixed within the machine **10** where desired) is delivered via line **15** from a source of cleaning solution in the form of a solution tank **16** adjacent to brushes **14** such as by a solution pump **18** in fluid communication with tank **16**. In the preferred form, machine **10** includes a recovery tank **26** and a suitable vacuum system including a solution pickup element **28** such as squeegee as diagrammatically shown for collecting solution from the surface to be cleaned and delivering such collected solution to recovery tank **26**.

[0025] In a most preferred form where machine **10** sweeps as well as wet scrubs the floor surface, a hopper **33** is positioned above and intermediate the first and second brushes **14** for receiving debris swept from the floor as brushes **14** are simultaneously moved in an operation direction parallel to the floor. It should be appreciated that hopper **33** allows solution and small particles to flow therethrough to the floor but retains debris and large particles which can be manually removed such as by sliding hopper **33** from machine **10** and emptying. However, hopper **33** can take other forms and/or could be eliminated in certain embodiments according to the preferred teachings of the present invention.

[0026] Machine **10** as previously described can be of a variety of types and forms, and the present invention is not intended to be limited to any particular type or form including but not limited to the type or form shown and/or described.

[0027] According to the teachings of the present invention, each brush **14** generally includes a cylindrical core **40** mounted for rotation about rotational axis **42**. In the most preferred form shown, cylindrical core **40** is in the form of a tube which is slideably received on spindles **44**. At least one of such spindles **44** of each brush **14** is rotated by a motor **46** through a suitable drive such as sheaves and a V-belt **48**. It should be appreciated that core **40** can have other forms as is known in the art. Similarly, core **40** can be driven by different manners as is known in the art according to the teachings of the present invention such as, but not limited to, by a single motor **46** while having drives resulting in the desired speed relationship, or the like. In any case, each cylindrical core **40** includes a cylindrical outer surface **50** having a core diameter D**3** and concentric to rotational axis **42** at a radial spacing equal to one half of core diameter D**3**.

[0028] In the most preferred form, core **40** includes a multiplicty of drilled tuft holes **52** extending radially into cylindrical outer surface **50**. Each of the tuft holes **52** has a diameter **52***a*. Each of tuft holes **52** receives a multiplicity of individual bristles B to define an individual tuft **54** extending radially from rotation axis **42**. According to the teachings of the present invention, tuft holes **52** and thus tufts **54** are arranged as a multiplicity of rows R. Specifically, in the form shown, rows R are spaced by a row spacing S circumferentially around cylindrical outer surface **50**, and in the most preferred form, row spacing S is equally spaced between each of rows R around the entire cylindrical outer surface **50**. Likewise, each of the rows R includes a multiplicity of tuft holes **52** and tufts **54** which are spaced by a tuft spacing I. In the most preferred form, tuft spacing I is equally spaced in each and every row R, and row spacing S is generally equal to tuft spacing I.

[0029] According to the teachings of the present invention, cylindrical brush **14** includes several features which cooperate together to produce synergistic results. One such feature is that rows R of spaced tufts **54** of bristles B are arranged in a spiral at an acute angle A**1** to the rotational axis of between 15 and 25° and preferably in the order of 20° when measured at surface **50** unrolled and lain flat. Spiraling tufts **54** minimize imprints of tufts **54** on the floor finish as occurs when tufts are arranged in straight rows across the brush.

[0030] Further, in the preferred form where each tuft **54** in brush **14** is formed by a multiplicity of individual bristles B received in drilled tuft hole **52** in core **40**, the diameter D**3** of core **40** of brush **14** is in the range of 2 to 5 inches and in the most preferred form in the order of 2.9 inches. The diameter **52***a* of drilled tuft hole **52** in core **40** is in the range of 0.25 to 0.375 inches and in the most preferred form in the order of 0.31 inches. The length of bristles B extending from tuft hole **52** is in the range of 1.25 to 1.75 inches and in the most preferred form in the order of 1.5 inches. The ratio of length of bristles B to the diameter of tuft drill hole **52** is in the range of 4.5:1 to 5:1 and in the preferred form in the order of 4.8:1. Each bristle B in the preferred form is formed from 0.008 inch crimped type 6.12 nylon in the preferred form. The crimp amplitude is around 0.025 inch and the pitch is around 0.11 inch. Bristles B could also be formed by polypropylene having a similar flex modulus or other water resistant bristle material according to the teachings of the present invention.

Likewise, although crimping adds fullness to tufts **54**, bristles B could be flagged to add fullness according to the teachings of the present invention. In addition to diameter, material and type, performance of tuft **54** is affected by length of bristles B and the number of tufts **54** per area. Specifically, the distance I between adjacent tufts **54** within the same row R is in the range of 0.50 inch to 0.75 inch and in the most preferred form is in the order of 0.59 inch. The exact distance I between tufts **54** is determined by the length of rows R along the working length D**1** of brush **14**. The length of rows R is divided by the preferred distance and rounded to the nearest whole number.

[0031] In the preferred form, the spacing S between rows R of spaced tufts **54** of bristles B is generally the same as the distance I between adjacent tufts **54** in rows R in the preferred form. The number of rows R should result in row patterns repeating itself at least once for each full rotation of brush **14**. In the preferred form, the number of rows R of tufts **54** is in the range of **14** to **18** rows R and in the most preferred form in the order of **16** rows R. As an example, a 16-row brush **14** could have either two or four identical groups of eight rows or four rows R, respectively. A 15-row brush **14** could have three identical pattern groups of five rows R each. An 18-row brush **14** could have either two or three identical groups of nine rows R or six rows R, respectively.

[0032] Additionally, tufts **54** are indexed such that tufts **54** in trailing rows R are indexed laterally by a distance T from tufts **54** in the preceding or leading row R. Distance T depends upon the number of rows R and the number of repeat patterns formed by the rows R. Particularly, distance T is equal to the distance I between tufts **54** in the same row R divided by the product of the number of rows R in turn divided by the number of repeat patterns. In the preferred form, distance T is of an amount no greater than in the order of one half of diameter **52***a* of tuft holes **52** in cylindrical outer surface **50** of brush **14** for receiving tufts **54** and not less than one ninth of diameter **52***a* of tuft holes **52** in cylindrical surface **50** of brush **14** for receiving the tufts **54**. In the most preferred form, distance T is in the order of one quarter of diameter **52***a* of tuft holes **52** in cylindrical outer surface **50** of brush **14** for receiving tufts **54**.

[0033] Furthermore in the most preferred form, at least one of brushes **14** is rotated by floor maintenance machine **10** faster than cylindrical brushes of conventional automatic scrubbers such that the tip speed of bristles B is faster in the present invention than in conventional automatic scrubbers. Specifically, cylindrical brushes of convention automatic scrubbers were typically rotated at 900 RPMs and resulted in individual tuft imprints on the floor finish. In the preferred form for brush **14** having a diameter D**2** in the order of 5.9 inches, the trailing brush **14** in the direction of travel is counter rotated at a speed in the range of 1200 to 1800 RPMs and preferably in the order of 1500 RPMs, and with the preferred bristle length resulting in a tip speed in the range of 1850 to 2750 feet per minute and preferably in the order of 2300 feet per minute. Such speeds according to the preferred form of the present invention synergistically resulted in polishing benefits which were not obtained at conventional speeds. However, it should be appreciated that in the preferred form, the angle A**1** and speed are related. For any given RPM, if angle A**1** is too shallow or too great, row effect or tuft imprints as experienced with conventional automatic scrubbers may result.

[0034] Further in the preferred form, the rotational speed of leading and trailing brushes **14** are different, with trailing brush **14** in the direction of travel rotating faster than the leading brush **14**. In the most preferred form, where trailing brush **14** rotates in the order of 1500 RPMs, the leading brush **14** is rotated in the order of 900 RPMs. It was surprisingly discovered that sweeping performance of machine **10** was better when brushes **14** were rotated at differing speeds, and the polishing benefit was still obtained if trailing brush **14** was rotated faster than conventional speeds.

[0035] Thus since the invention disclosed herein may be embodied in other specific forms without departing from the spirit or general characteristics thereof, some of which forms have been indicated, the embodiments described herein are to be considered in all respects illustrative and not restrictive.

1. Brush for a floor maintenance machine comprising, in combination: a cylindrical core having a rotational axis and a cylindrical outer surface concentric to the rotational axis at a radial spacing, with the cylindrical core adapted to be mounted to a floor maintenance machine for rotation about the rotation axis; and a multiplicity of rows of a multiplicity of tufts of bristles, with the multiplicity of rows being equally circumferentially spaced and arranged at an acute angle to the rotational axis to create a spiral, with the tufts being equally spaced by a tuft spacing in each of the multiplicity of rows, with the tufts of an adjacent trailing row being indexed laterally from a leading row by an index distance less than one half of the tuft spacing.

2. The brush of claim **1** with the multiplicity of rows being equally spaced by a row spacing generally equal to the tuft spacing.

3. The brush of claim **2** with the multiplicity of rows repeating in at least two identical row patterns.

4. The brush of claim **3** with each of the multiplicity of tufts comprising a tuft hole extending radially into the cylindrical outer surface of the core, with the tuft hole having a hole diameter; and a plurality of bristles received in the tuft hole, with the index distance being one half of the hole diameter or less.

5. The brush of claim **4** with the bristles extending from the core hole by a length, with a ratio of the length of the bristles to the hole diameter being in the range of 4.5:1 to 5:1.

6. The brush of claim **5** with the acute angle being between 15° and 25° when the cylindrical outer surface is unwrapped from the rotational axis and lain flat.

7. The brush of claim **6** with each of the plurality of bristles formed of crimped type nylon having a crimp amplitude around 0.025 inch and a pitch around 0.11 inches.

8. A floor maintenance machine utilizing the brush of claim **1**.

9. Method of maintaining a floor comprising:

rotating a leading cylindrical brush about a leading rotational axis parallel to the floor at a first rotational speed, with the leading cylindrical brush having tufts of bristles extending radially from the leading rotational axis;

simultaneously counter rotating a trailing cylindrical brush about a trailing rotational axis parallel to the floor at a second rotational speed greater than the first rotational speed, with the trailing cylindrical brush having tufts of bristles extending radially from the trailing rotational axis, with the leading and trailing rotational axes being parallel;

providing a hopper intermediate the leading and trailing cylindrical brushes for receiving debris swept from the floor by the leading and trailing cylindrical brushes; and

simultaneously moving the leading and trailing cylindrical brushes in an operation direction parallel to the floor with the leading cylindrical brush being forward in the operation direction of the trailing cylindrical brush.

10. The method of claim **9** wherein counter rotating the trailing cylindrical brush comprises counter rotating the trailing cylindrical brush of identical construction as the leading cylindrical brush.

11. The method of claim **10** wherein the tufts of bristles of each of the trailing and leading cylindrical brushes are spaced and are arranged in a multiplicity of rows, with the multiplicity of rows being circumferentially spaced around the rotational axes, with the multiplicity of rows being arranged at an acute angle to the rotational axis to create a spiral.

12. The method of claim **11** wherein counter rotating the trailing cylindrical brush comprises counter rotating the trailing cylindrical brush at the second rotational speed in the order of 1200 to 1800 RPMs.

13. The method of claim **12** wherein the multiplicity of rows are equally circumferentially spaced, with the tufts being equally spaced by a tuft spacing in each of the multiplicity of rows, and the tufts being equally spaced by a tuft spacing in each of the multiplicity of rows, with the tufts of an adjacent trailing row being indexed laterally from a leading row by an index distance less than one half of the tuft spacing.

14. A floor maintenance machine utilizing the method of claim **9**.

15. Method of maintaining a floor comprising:

rotating a trailing cylindrical brush about a trailing rotational axis parallel to the floor surface at a rotational speed in the order of 1200 to 1800 RPMs, with the trailing cylindrical brush having tufts of bristles extending radially from the trailing rotational axis; and

moving the trailing cylindrical brush in an operation direction parallel to the floor.

16. The method of claim **15** wherein the tufts of bristles are spaced and are arranged in a multiplicity of rows, with the multiplicity of rows being circumferentially spaced around the rotational axes, with the multiplicity of rows being arranged at an acute angle to the rotational axis to create a spiral.

17. The method of claim **16** wherein the multiplicity of rows are equally circumferentially spaced, with the tufts being equally spaced by a tuft spacing in each of the multiplicity of rows, and the tufts being equally spaced by a tuft spacing in each of the multiplicity of rows, with the tufts of an adjacent trailing row being indexed laterally from a leading row by an index distance less than one half of the tuft spacing.

18. The method of claim **17** further comprising:

simultaneously counter rotating a leading cylindrical brush about a leading rotational axis parallel to the floor surface at a first rotational speed, with the leading cylindrical brush having tufts of bristles extending radially from the leading rotational axis, with the leading and trailing rotational axes being parallel;

providing a hopper intermediate the leading and trailing cylindrical brushes for receiving debris swept from the floor by the leading and trailing cylindrical brushes; and

moving the leading cylindrical brush in the operation direction parallel to the floor, with the leading cylindrical brush being forward in the operation direction of the trailing cylindrical brush.

19. The method of claim **18** wherein rotating the trailing cylindrical brush comprises rotating the trailing cylindrical brush of identical construction as the leading cylindrical brush.

20. A floor maintenance machine utilizing the method of claim **15**.

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