



(51) International Patent Classification:
A47L 11/16 (2006.01)

(21) International Application Number:
PCT/US2015/037239

(22) International Filing Date:
23 June 2015 (23.06.2015)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
62/015,691 23 June 2014 (23.06.2014) US

(71) Applicant: DIVERSEY, INC. [US/US]; 8310 16th Street,
M/S 509, P.O. Box 902, Sturtevant, WI 53177-0902 (US).

(72) Inventors: RILEY, Maynard, J.; 4225 Mona Park Road,
Racine, WI 53405 (US). COCKING, Andrew; 160 Morn-
ingside Drive, Ben Lomond, CA 95005 (US). NEU-
MANN, Michael, D.; 5411 Westmore Drive, Racine, WI
53406 (US).

(74) Agent: NODOLF, Aaron, K.; Michael Best & Friedrich
LLP, 100 East Wisconsin Avenue, Suite 3300, Milwaukee,
WI 53202-4108 (US).

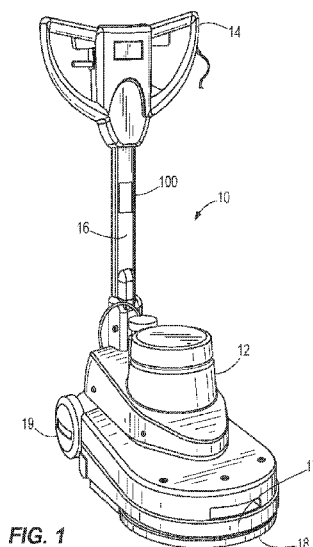
(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY,
BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM,
DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR,
KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG,
MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM,
PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC,
SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ,
TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU,
TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE,
DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU,
LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK,
SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,
GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— with international search report (Art. 21(3))

(54) Title: SYSTEM AND METHOD FOR DETERMINING A LEVEL OF POLISH



(57) Abstract: A machine adapted to polish a surface, the machine including a driven implement including a tool configured to en-
gage and polish the surface, and a module coupled to the implement and including a processing system and a sensor, the sensor posi-
tioned to detect data associated with operation of the implement and in communication with the processing system, the data detected
by the sensor is transmitted to the processing system, and the processing system is programmed to determine an approximate level of
surface polish based on the data detected by the sensor.



SYSTEM AND METHOD FOR DETERMINING A LEVEL OF POLISH

FIELD OF THE INVENTION

[0001] The present invention relates to floor burnishing or polishing systems. More specifically, the present invention relates to a system for determining a level of floor polish during operation of a floor burnishing or polishing system.

BACKGROUND

[0002] Systems for burnishing or polishing floors are generally known. These systems typically include a motorized floor burnishing or polishing machine that includes an abrasive disc or pad, or a series of abrasive discs or pads. The discs or pads each have incrementally finer levels of coarseness, grit size, or buffing material. The machine moves (e.g., rotates) the disc or pad at high speed, for example in the range of 175 to 200 revolutions per minute. In other applications, the machine may use a reciprocating, oscillating, or orbital motion. While the disc or pad is rotated, a user applies the machine over a given section of a floor for a predetermined period, for example a fixed number of machine passes or a preset amount of operating time over the given section of floor. After the machine has been applied over the given section of floor for the predetermined passes or time period, the user automatically moves on to the next step in the process (e.g., applying a floor polish solution to the floor, or changing to the next finer (or less coarse) disc or pad in the series and then repeating the operational process over the same given section of floor). The process repeats until the user cycles through all of the discs or pads in the series over the same given section of floor.

[0003] While known systems result in polished floors, these systems have certain limitations. For example, known systems do not dynamically determine or measure the smoothness, gloss, or relative level of polish during operation of the floor polishing machine. Moreover, these systems do not account for the starting condition of the floor, such as the initial roughness or gloss, or the floor condition progress (i.e. floor smoothness or gloss) during polishing. Accordingly, two different sections of floor may require different amounts of polishing to achieve the same desired or targeted level of polish. For example, the different sections of floor may not need to be polished for the entire predetermined time period or for the predetermined number of passes, and

the sections may not need to be polished at all with one or more of the discs or pads that are called for in existing systems.

SUMMARY OF THE INVENTION

[0004] The invention provides in one aspect, a machine including a driven implement that has a tool configured to engage and polish the surface. The machine also includes a module that is coupled to the implement and that has a processing system and a sensor. The sensor is positioned to detect data associated with operation of the implement and is in communication with the processing system. The data detected by the sensor is transmitted to the processing system, and the processing system is programmed to determine an approximate level of surface polish based on the data detected by the sensor.

[0005] The invention provides, in another aspect, a method of dynamically measuring the level of floor polish while polishing a floor. The method includes detecting data with a sensor associated with operation of a driven implement including a tool configured to engage and polish a surface, transmitting the data detected by the sensor to a processing device, and determining an approximate level of surface polish with the processing device based on the data detected by the sensor.

[0006] In another aspect, the invention provides a system that determines a level of polish on a floor. The system includes a machine that has an implement with a tool engageable with the floor and moved via movement of the implement to polish the floor. The system also includes a module that is coupled to the implement and that has a processing system and a sensor. The sensor positioned to detect data associated with operation of the implement and in communication with the processing system. The data detected by the sensor is transmitted to the processing system, and the processing system is programmed to determine an approximate level of surface polish based on the data detected by the sensor.

[0007] Other features and aspects of the invention will become apparent by consideration of the following detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] FIG. 1 is a perspective view of an exemplary floor polishing machine embodying the invention.

[0009] FIG. 2 is a perspective view of another exemplary floor polishing machine for polishing a floor and embodying the invention.

[0010] FIG. 3 is a perspective view of another floor polishing machine for polishing a floor and embodying the invention.

[0011] FIG. 4 is a logic diagram of an exemplary process of determining the level of polish on the floor during operation of the floor polishing machine of FIGS. 1-3.

[0012] FIG. 5 is a graph illustrating exemplary acceleration data collected from the floor polishing machine of FIG. 1 during operation of the machine over a period of time.

[0013] FIG. 6 is a graph illustrating the data of FIG. 5 after being normalized by calculating a mean or average of all of the data points associated with a period of time, and then subtracting that mean or average from each individual data point in the period of time.

[0014] FIG. 7 is a graph illustrating exemplary acceleration data collected from a sensor associated with the machine during operation of the floor polishing machine of FIG. 1 over a period of time.

[0015] FIG. 8 is a graph illustrating the data of FIG. 7 after determining peaks of a fast Fourier transform.

[0016] FIG. 9 is a schematic diagram of the floor polishing machine of FIGS. 1-3 incorporating an exemplary module.

[0017] Before any embodiments of the present invention are explained in detail, it should be understood that the invention is not limited in its application to the details or construction and the arrangement of components as set forth in the following description or as illustrated in the drawings. The invention is capable of other embodiments and of being practiced or of being

carried out in various ways. It should be understood that the description of specific embodiments is not intended to limit the disclosure from covering all modifications, equivalents and alternatives falling within the spirit and scope of the disclosure. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

DETAILED DESCRIPTION

[0018] The invention illustrated in the Figures and disclosed herein is generally directed to one or more examples of embodiments of a machine and system for determining a level of floor polish while operating a floor polishing machine 10. The system analyzes real time operational conditions of the polishing machine 10, and provides a user feedback based on the operational conditions. The feedback includes an indication of when a surface or floor 50 has reached a desired or targeted level of polish. By providing this feedback, a user operates the floor polishing machine 10 over a given section of floor based on the current condition of the floor (e.g. the achieved level of floor polish). This advantageously reduces the amount of time a user is required to operate the floor polishing machine 10, as the user is basing operation on the actual level of achieved floor polish, instead of operating for a predetermined period. Since labor costs can make up more than 85% of the total cost of floor care expenses, reducing the amount of operating time of the floor polishing machine 10 reduces labor costs, realizing cost savings. In addition, by knowing when a floor 50 is polished to a gloss level, the floor 50 will generate a uniform level of shine.

[0019] For ease of discussion and understanding, the following detailed description refers to a floor polishing machine 10, but it should be understood that the floor polishing machine 10 can include a polishing machine or a burnishing machine. Furthermore, it should be appreciated that the term floor polishing machine 10 may include any suitable machine used to burnish or polish a surface, such as a floor, including, but not limited to, a burnisher like the TASKI ERGODISC 2000 manufactured by Diversey, Inc., a SWINGO machine like the TASKI ERGODISC 175 manufactured by Diversey, Inc., a buffer, a polisher, or a scrubber or auto-scrubber. In addition, the term floor polishing machine 10 may include any known or future developed floor polishing or burnishing process, including, but not limited to, wet grinding, dry grinding, wet polishing,

dry polishing, or any process combined with one or more liquid or non-liquid film forming chemicals or compounds.

[0020] In addition, the detailed description refers to a floor 50, and it should be appreciated that reference herein to a floor 50 is provided for purposes of illustration and description only. Aspects of the present invention are not limited to a specific substrate or surface to be polished or burnished, and can be incorporated into any machine or device that polishes a surface (regardless of whether the surface is a floor intended to be walked on). Furthermore, a floor 50 may include, but is not limited to, terrazzo, bare concrete, polished concrete, decorative concrete (including stained or dyed concrete), granite, marble, travertine, porous or non-porous stone material, non-stone material, or any other substrate or surface to be polished or burnished.

[0021] The detailed description and claims refer to polish and polishing. The terms are intended to describe making a surface smooth and increasing gloss by rubbing (i.e. using friction). The terms polish and polishing encompass other ways to effect a smooth and glossy finish, including burnishing.

[0022] The invention is described in detail by referring to a level of floor polish. The level of floor polish is intended to describe the smoothness, gloss, sheen, shine, or appearance of the floor 50 achievable with an abrasive disc or pad, or other abrasive component or material (i.e. slurry, powder, etc.) used to polish the floor. It should be appreciated that different abrasive discs, pads, components, or materials will achieve a different level of floor polish. For example, polishing a floor 50 with a 100-grit abrasive disc will result in a level of floor polish that will be less glossy than polishing a floor 50 with a finer, 800-grit abrasive disc. Each abrasive disc or pad will have a desired or targeted level of polish, which refers to the level of floor polish achievable with that abrasive disc or pad. When a series of abrasives discs or pads are used consecutively, each abrasive disc or pad will have a different desired or targeted level of polish. Typically, with each increasingly less coarse or less abrasive or finer abrasive disc or pad in the series, the desired or targeted level of polish of each abrasive disc or pad increases. When an abrasive disc or pad in a series achieves its desired or targeted level of polish, the user changes to the next abrasive disc or pad in the series to further increase the level of floor polish (i.e. increase the smoothness or gloss of the floor).

[0023] Referring now to FIG. 1, an example of a floor polishing machine 10 is provided. The floor polishing machine 10 includes a housing 12 coupled to a handle 14 by a stem 16. The handle 14 provides operational user controls for the machine 10. The machine also includes a driven implement 17 (e.g., driven to rotate, reciprocate, oscillate, or orbital) that supports or attaches a tool 18 on the underside of the housing 12. The tool 18 is configured to engage and polish the floor 50, and may be an abrasive disc or pad. The housing 12 also includes a motor and drive assembly (not shown) that are in operable connection with the implement 17. As such, user controls on the handle 14 provide user operational control of the machine 10, including movement of the implement 17 and the tool 18. The housing 12 can include one or more wheels 19 to facilitate movement of the machine 10 across the floor 50.

[0024] The tool 18 may be a standalone tool 18, or may be one of a plurality of discs or pads 18 provided in a series. The tool 18 may be any constructed of any suitable abrasive material for polishing the floor 50. For example, the tool 18 may include a diamond material bound or adhered by a resin or any other suitable adhesive. In other examples of embodiments, the tool 18 may include other abrasive materials, including metallic abrasives, such as silicon carbide, aluminum oxide, cubic boron nitride, that are impregnated, coated, or otherwise connected to the tool 18. The tool 18 may be formed of any desired or suitable shape or size. The tool 18 and may include one or more protrusions on the surface contacting the floor 50. The tool 18 may have a grit that ranges between approximately 200 and approximately 800 grit, although the grit may be outside of this range. Similarly, the tool 18 may be a double-dipped diamond pad. The tool 18 may have a grit that ranges between approximately 1000 and approximately 4000, although the grit may be outside of this range.

[0025] FIG. 2 illustrates the floor polishing machine 10 as a SWINGO machine. FIG. 3 illustrates the floor polishing machine 10 as a burnisher. The floor polishing machine 10 of both FIGS. 2 and 3 is operated by a user over a floor 50 to polish the floor 50. In some examples, one or both of the SWINGO machine or the burnisher may be used separately or together to polish the floor 50.

[0026] Referring back to FIG. 1, the floor polishing machine 10 includes a module 100 coupled to the stem 16. However, in other examples, the module 100 may be provided on other

components of the machine 10, such as the housing 12 or handle 14. In addition, the module 100 may be two or more separate components provided at separate locations on the floor polishing machine 10. For example, a portion of the module 100 may be provided on the housing 12, the handle 14, the stem 16, and/or other components of the machine 10. In other examples, the module 100 may be integrated into the machine 10, or may be a component (e.g., a processing device such as a tablet or smartphone) that can be fixed or removably attached to the machine 10. The module 100 also can encompass two or more components, with at least one component (e.g., a tablet or smartphone) that is separate from and that is in communication with the machine 10.

[0027] Referring to FIG. 9, the module 100 includes a sensor 102, a processing system 104, and a notification device 106. The sensor 102 is in communication with the processing system 104, for example by a first communication link 108. The processing system 104 is in communication with the notification device 106, for example by a second communication link 110. During operation of the floor polishing machine 10, the sensor 102 detects data associated with operation of the machine 10 and/or the implement 17, and transmits the data to the processing system 104 via the first communication link 108. The processing system 104 is programmed to determine the approximate level of floor polish (or surface polish) based on the data detected by the sensor 102. At a predetermined level of floor polish (or surface polish), the processing system 104 transmits a signal to the notification device 106 via the second communication link 110. The notification device 106 is coupled to the machine 10. The notification device 106 notifies the user that a target level of floor polish (or gloss level) has been achieved.

[0028] The sensor 102 includes an accelerometer that detects and/or measures vibration from the floor polishing machine 10. The floor polishing machine 10 generates vibration from the moving components when the associated tool 18 engages the surface or floor 50 during polishing. The accelerometer detects and/or measures this vibration as acceleration in units of “g” (acceleration due to gravity, or “g-force”) or a unit of distance per second squared, such as meters per second squared (m/s^2) or feet per second squared (ft/s^2). The sensor 102 may include one or more accelerometers in communication with the module 100. In other examples, the sensor 102 may include one or more other sensors that detect data associated with the operation of the machine 10 and/or the implement 17.

[0029] The processing system 104 receives the data detected or generated by the sensor 102. The processing system 104 may further process the data, analyze the data, and/or store the data. Additional details regarding processing and analysis of the data are discussed in further detail below. The processing system 104 may be a programmable computer system including random access memory (RAM), a computer readable storage medium or storage device or hard drive, and a processor. The processing system 104 may include executable instructions (or a computer readable code) to acquire raw data detected and/or generated by the sensor 102, store the raw data from the sensor 102, process the raw data from the sensor 102, analyze the processed data, store the processed data, and/or execute commands based on the processed data analysis. In one or more examples, the processing system 104 may be any known or future developed programmable computer processor system suitable to process and analyze the data as disclosed herein. Further, in one or more examples, the computer readable storage medium may include any data storage device which can store data that can be thereafter read by a computer system. Examples of computer readable storage medium may include read-only memory, CD-ROM, CD-R, CD-RW, DVD, DVD-RW, magnetic tapes, Universal Serial Bus (USB) flash drive, or any other optical or other suitable data storage device. The computer readable storage medium may also be distributed over a network coupled to or in communication with the processing system 104 so that the computer readable code is stored and executed in a distributed fashion. In various embodiments, the processing system 104 may be located separate and distinct from floor polishing machine 10, for example in a hand held device such as a smart phone or tablet.

[0030] The notification device 106 is in communication with the processing system 104 so that commands from the processing system 104 can be transmitted to the notification device 106. The processing system 104 may provide a command to the notification device 106 (e.g., instruct the notification device 106 to operate) to provide notice to the user that a given section of floor 50 has attained a desired or targeted level of polish. The notification device 106 may be a visual and/or an audible notice to the user. For example, the visual cue may be a light that illuminates or blinks. The audible cue may be a constant or intermittent sound. In other examples, the notification device 106 may be an automated termination of operation of one or more components of the machine 10, including stopping movement of the implement 17 (and associated tool 18), terminating operation of the motor and/or drive assembly, or terminating operation by “shutting down” the machine 10. In various examples, the notification device 106

may be provided on the module 100, handle 14, stem 16, or at any other location associated with the machine 10 suitable for providing notice to the user.

[0031] In operation, the floor polishing machine 10 generates vibration as the implement 17 (and associated tool) engages and polishes the surface, such as floor 50. As the machine 10 polishes a given section of the floor 50, the level of floor polish increases (i.e. the surface becomes smoother and the gloss increases). As the level of floor polish increases, the vibration generated during operation of the floor polishing machine 10 decreases. By measuring and analyzing vibration data detected by the accelerometer during polishing, the approximate level of floor polish may be determined. The determination is based on predictable changes to accelerometer data during the polishing process as the level of floor polish of the floor 50 increases.

[0032] FIG. 4 illustrates an example of a level of polish application 200 executed by the processing system 104 to determine an approximate level of polish of the floor 50 during operation of the floor polishing machine 10. The operation steps may be executable instructions provided as a program or application or module or computer readable code that are provided on the machine-readable medium carried or stored or operated in association with the processing system 104. The executable instructions may be prepared or written in any suitable programming language.

[0033] Referring to FIG. 4, the application 200 includes a series of processing instructions or steps that are depicted in flow diagram form. At step 202, the user begins operation of the floor polishing machine 10 over a section or portion of the floor 50. The user begins operation by powering on the floor polishing machine 10 or initiating movement of the implement 17 and associated tool 18 (i.e. discs or pads 18).

[0034] Next, at step 204, the application initiates a data delay timer. The data delay timer is a timer provided with a predetermined amount of time before transmitting data from the sensor 102 to the processing system 104. The delay is provided to minimize the collection of outlier data or false signal components from the sensor 102 during the initial period of operation of the floor polishing machine 10. Outlier data may be present during the initial period of operation due to excess pitch, yaw, and roll (or x-, y-, and z-axis) of the floor polishing machine 10. A user

needs an initial amount of time to become oriented with operation of the floor polishing machine 10 and to enter into an “operational rhythm” (i.e. normal operation of the floor polishing machine 10 that eliminates excess or unneeded movements of the machine 10). Although optional, the data delay timer accounts for this initial period of operation. The data delay timer may be a “count-up” timer, wherein the timer begins at zero and counts up to a predetermined value, or a “count-down” timer, wherein the timer begins at a predetermined value and counts down to zero. The predetermined value may be any suitable or desired value, for example twenty seconds. At step 206, the data delay timer is complete. As such, the timer reaches the predetermined value (in a “count-up” timer), or reaches zero (in a “count-down” timer).

[0035] At step 208, the application 200 transmits data from the sensor 102 to the processing system 104. The transmitted data may be any suitable or desired amount of data at any suitable or desired data collection frequency. The amount of data collected and the data collection frequency by the sensor 102 may be predetermined. For example, the sensor 102 may collect approximately 1500 data points during a given 15-second segment of time. The application 200 may also stamp or associated each data point with a date and/or time, and store the data in association with the processing system 104. The date and/or time stamp provides operating time of the floor polishing machine 10, while also identifying the amount of time the floor polishing machine 10 spends at a given section of the floor 50. FIG. 5 illustrates an example of data transmitted by the sensor 102, and specifically acceleration data transmitted by the accelerometer.

[0036] Referring back to FIG. 4, at step 210 the application 200 determines a machine parameter based on the data transmitted from the sensor 102 to the processing system 104. The determination of the machine parameter may include one or more calculations on the data transmitted in step 208. For example, the application 200 may determine an average machine acceleration for a period of time of operation as the machine parameter. To determine this machine parameter, the application 200 may normalize the transmitted data. As referenced herein, “normalize” involves calculating a mean or average of all of the data points associated with a period of time, and then subtracting that mean or average from each individual data point in the period of time. FIG. 6 illustrates a graphical example of normalized acceleration data illustrated in FIG. 5. The data in FIG. 6 was normalized in 15-second blocks of time, with the

mean or average being graphically depicted as zero. After normalizing the data, the application 200 may perform further calculations. For example, each of the normalized data points for a period of time may be calculated as an absolute value (i.e. making all positive and negative values a positive value). The average of the absolute values may then be calculated (and stored) as the average machine acceleration for a period of time of operation. This process repeats as a dynamic process, with the application 200 continuing to determine the machine parameter by performing calculations, including those discussed above, on the data detected by the sensor 102 and transmitted to the processing system 104 at a predetermined frequency (or as the data is transmitted). The application 200 may collect and/or store data, including the raw transmitted data or the data resulting from the calculations.

[0037] At step 212, the application 200 analyzes the machine parameter determined at step 210. The analysis may include additional calculations, a comparison of the machine parameter against a predetermined value, a comparison of changes in the machine parameter over time, or a determination of the approximate level of floor polish (or surface polish). For example, the analysis may include calculating a percent decrease in acceleration based on changes in the normalized average machine acceleration over consecutive periods of time. The analysis may also involve calculating cumulative average of all the data points, or the normalized data points.

[0038] At step 214, the application 200 determines whether the analysis of the machine parameter performed in step 210 corresponds to an approximate level of floor polish (or surface polish). For example, the application 200 determines whether a percent decrease or decrease in cumulative average acceleration is reached that corresponds to a predetermined target gloss level for the given section of the floor 50.

[0039] If the application 200 determines at step 214 that the predetermined target gloss level for the given section of the floor 50 has been attained, the application 200 provides a notification to the user through the notification device 106 at step 216. At step 216, the application 200 may provide a signal or other communication initiating the notification device 106. If the application 200 determines at step 214 that the predetermined target gloss level for the given section of the floor 50 has not been attained, the application 200 returns to step 208 and the process repeats. It should be appreciated that the cumulative average acceleration that corresponds to a

predetermined target gloss level may be an absolute value or parameter, a derived value or parameter, or may be determined by a difference based on other data points.

[0040] The application 200 may perform one or more additional or alternate determinations of a machine parameter and associated analysis at steps 210-214. For example, the application 200 may calculate a machine velocity based on the measured machine acceleration data. Velocity is provided in units of distance per second, such as meters per second (m/s) or feet per second (ft/s). It should be appreciated that instead of being calculated, machine velocity may be measured by the module 100 having an associated sensor 102. As steps 210-212, the velocity data may be normalized and analyzed in the same manner discussed above in association with the acceleration data. At step 214, the application 200 determines whether a percent decrease or decrease in cumulative average velocity is reached that corresponds to a predetermined target gloss level. If the determination is yes, it does, the application 200 moves to step 216, providing a notification to the user through the notification device 106. If the determination is no, it does not, the application 200 returns to step 208 and the process repeats.

[0041] Another example of an additional or alternate calculation and analysis at steps 210-214 includes a Fourier transform calculation, and more specifically a fast Fourier transform (“FFT”) calculation. While an FFT is specifically discussed below, the Fourier transform calculation may include other calculations, including, but not limited to, a discrete Fourier transform calculation, a fractional Fourier transform calculation, or a combination of multiple algorithms such as those used in association with the Fastest Fourier Transform in the West (“FFTW”) software library.

[0042] The FFT converts time-domain data to frequency-domain data. For example, floor polishing machines 10 that rotate or spin a tool 18 (i.e. discs or pads 18) have a periodic component in accelerometer data corresponding to the rotational speed of the tool 18. For a floor polishing machine 10 that rotates at a speed of 175 revolutions per minute (“RPM”) has a periodic component that corresponds to approximately 3 Hertz (Hz) or cycles per second (calculated by dividing 175 RPM by 60 seconds). The periodic component may change based on the RPM of the rotatable component of the floor polishing machine 10. The periodic component also may be defined by different acceleration-based data depending on whether the implement 17 oscillates, slides, vibrates, or performs some other movement.

[0043] At step 210, a machine parameter associated with acceleration data from the sensor 102 is determined using the FFT. The FFT may be performed on the data approximately every twenty seconds at an approximate sampling rate of 100 Hz. The FFT acceleration data provides distinct peaks in amplitude at certain intervals. FIG. 7 illustrates a graph of acceleration data acquired from the sensor 102, while FIG. 8 illustrates a graph following calculation of a FFT of the data from FIG. 7. Referring to FIG. 8, distinct peaks in amplitude are provided at approximately 3, 6, and 11.7 Hz. Referring back to FIG. 4, at step 210, the application 200 may further separately store the three consecutive largest FFT acceleration data points to establish the peak amplitude, and/or calculate a cumulative average of the FFT acceleration data. At step 212, the application 200 analyzes the FFT acceleration data, FFT acceleration peak amplitude, and/or cumulative average of the FFT acceleration data. At step 214, the application 200 determines whether the analyzed data corresponds to a predetermined target gloss level or an approximate level of gloss (or surface polish). For example, the determination may be based on a calculated correlation for the drop in peak amplitude as a function of time. If the determination is that the analyzed data corresponds to the target gloss level (i.e. “Yes” at step 214), the application 200 moves to step 216 and provides a notification to the user through the notification device 106. If the analyzed data does not correspond to the target gloss level (i.e. “No” at step 214), the application 200 returns to step 208 and the process repeats.

[0044] It should be appreciated that during at least steps 210, 212, and 214, the application 200 continues to collect data from the sensor 102 as described in association with step 208. In addition, in various embodiments, additional logic or processing steps may be incorporated into the application 200. For example, the application 200 may include a series of steps providing notice to a user if data is not being generated by the sensor 102, or collected by the processing system 104.

[0045] After notification is provided to the user at step 216, the user may move the floor polishing machine 10 to another section of floor 50 and repeat the polishing process until the floor 50 is polished, the user may change the tool 18 on the floor polishing machine 10 to the next less coarse (or finer grit) disc or pad in the series and then repeat the polishing process until the floor 50 is polished, or the user may complete operation of the floor polishing machine 10.

[0046] The floor polishing machine 10 and associated module 100 and level of polish application 200 actively and dynamically analyze data from the sensor 102 and determine the relative smoothness or gloss of the floor 50 based on the data. Continued operation of the floor polishing machine 10 is based on the level of polish achieved on the floor 50, instead of operating the machine for a predetermined period. Sections of floor 50 that are polished by the machine 10 with the module 100 and the application 200 receive only the amount of polishing that is needed to achieve the desired gloss. In addition, the end level of polish of the floor 50 will be standardized because the application 200 accounts for the initial level of polish of the floor 50 prior to initiating the polishing process.

CLAIMS

1. A machine adapted to polish a surface, the machine comprising:
a driven implement including a tool configured to engage and polish the surface; and
a module coupled to the implement and including a processing system and a sensor, the sensor positioned to detect data associated with operation of the implement and in communication with the processing system,
wherein the data detected by the sensor is transmitted to the processing system, and
wherein the processing system is programmed to determine an approximate level of surface polish based on the data detected by the sensor.
2. The machine of claim 1, wherein the data includes one or both of an acceleration of the implement and a velocity of the implement.
3. The machine of claim 2, wherein, in response to the data, the processing system is programmed to determine a machine parameter including one or any combination of 1) an average acceleration associated with the implement, 2) an average velocity associated with the implement, and 3) an average amplitude of Fourier transform peaks associated with acceleration of the implement, and wherein the processing system is programmed to output the approximate level of surface polish based on a change in the machine parameter.
4. The machine of claim 3, wherein the change in the machine parameter is determined based on the data transmitted from the sensor to the processing device over a period of time.
5. The machine of claim 3, wherein the Fourier transform used in determining the average amplitude of peaks includes one or any combination of 1) fast Fourier transform, 2) discrete Fourier transform, 3) fractional Fourier transform, and 4) Fastest Fourier Transform in the West.
6. The machine of claim 1, wherein the sensor includes an accelerometer configured to detect an acceleration of the implement.

7. The machine of claim 6, wherein the processing system is programmed to determine a machine parameter based on the acceleration of the implement, and wherein the machine parameter includes an average amplitude of fast Fourier transform peaks associated with acceleration of the implement, and wherein the processing system is programmed to output the approximate level of surface polish based on a change in the machine parameter.
8. The machine of claim 7, wherein the change in the machine parameter includes a drop in the average peak amplitude as a function of time.
9. The machine of claim 6, wherein the processing system is programmed to determine an average acceleration of the implement and programmed to compare the average acceleration to a predetermined value to determine the approximate level of surface polish.
10. The machine of claim 6, wherein the processing system is programmed to determine an average velocity of the implement and programmed to compare the average velocity to a predetermined value to determine the approximate level of surface polish.
11. The machine of claim 1, wherein the approximate level of surface polish corresponds to a target gloss level of the surface.
12. The machine of claim 11, further comprising a handle and a stem positioned to couple the handle to the implement.
13. The machine of claim 12, wherein the module includes a notification device coupled to the handle, and wherein the notification device is in communication with the processing system to notify a user when the target gloss level has been achieved.
14. The machine of claim 13 wherein the notification device includes a visual notification.
15. The machine of claim 13, wherein the notification device includes an audible notification.

16. A method of determining a level of polish on a surface while polishing the surface, the method comprising:

detecting data with a sensor associated with operation of a driven implement including a tool configured to engage and polish a surface;

transmitting the data detected by the sensor to a processing device;

determining an approximate level of surface polish with the processing device based on the data detected by the sensor.

17. The method of claim 16, further comprising determining a machine parameter in response to the data in the transmitting step, the machine parameter includes one or any combination of 1) an average acceleration associated with the implement, 2) an average velocity associated with the implement, and 3) an average amplitude of Fourier transform peaks associated with acceleration of the implement.

18. The method of claim 17, wherein the Fourier transform used in determining the average amplitude of peaks includes one or any combination of 1) fast Fourier transform, 2) discrete Fourier transform, 3) fractional Fourier transform, and 4) Fastest Fourier Transform in the West.

19. The method of claim 16, further comprising determining an average acceleration of the implement in response to the data in the transmitting step.

20. The method of claim 19, further comprising comparing the average acceleration to a predetermined value to determine the approximate level of surface polish.

21. The method of claim 16, further comprising determining an average velocity of the implement in response to the data in the transmitting step.

22. The method of claim 21, further comprising comparing the average velocity to a predetermined value to determine the approximate level of surface polish.

23. The method of claim 16, further comprising determining an average amplitude of fast Fourier transform peaks associated with an acceleration of the implement detected with the sensor.

24. The method of claim 23, further comprising comparing the change in the average peak amplitude as a function of time to determine the approximate level of surface polish.
25. The method of claim 16, further comprising determining whether the approximate level of surface polish corresponds to a target gloss level of the surface.
26. The method of claim 25, further comprising notifying a user that the target gloss level of the surface has been achieved.
27. The method of claim 16, wherein the detecting step further comprises detecting data with a sensor associated with vibration generated by a driven element while the tool is engaging and polishing the surface.
28. A system configured to determine a level of polish on a floor while polishing the floor, the system comprising:
- a machine including an implement having a tool, the tool engageable with the floor and movable via movement of the implement to polish the floor; and
 - a module coupled to the implement and including a processing system and a sensor, the sensor positioned to detect data associated with operation of the implement and in communication with the processing system,
 - wherein the data detected by the sensor is transmitted to the processing system, and
 - wherein the processing system is programmed to determine an approximate level of surface polish based on the data detected by the sensor.
29. The system of claim 28, wherein the data includes one or both of an acceleration of the implement and a velocity of the implement.
30. The system of claim 29, wherein, in response to the data, the processing system is programmed to determine a machine parameter including one or any combination of 1) an average acceleration associated with the implement, 2) an average velocity associated with the implement, and 3) an average amplitude of Fourier transform peaks associated with acceleration of the implement, and wherein the processing system is programmed to output the approximate level of surface polish based on a change in the machine parameter.

31. The system of claim 30, wherein the Fourier transform used in determining the average amplitude of peaks includes one or any combination of 1) fast Fourier transform, 2) discrete Fourier transform, 3) fractional Fourier transform, and 4) Fastest Fourier Transform in the West.
32. The system of claim 30, wherein the change in the machine parameter is determined based on the data transmitted from the sensor to the processing device over a period of time.
33. The system of claim 28, wherein the sensor includes an accelerometer configured to detect an acceleration of the implement.
34. The system of claim 33, wherein the processing system is programmed to determine a machine parameter based on the acceleration of the implement, and wherein the machine parameter includes an average amplitude of fast Fourier transform peaks associated with acceleration of the implement, and wherein the processing system is programmed to output the approximate level of surface polish based on a change in the machine parameter.
35. The system of claim 34, wherein the change in the machine parameter includes a drop in the average peak amplitude as a function of time.
36. The system of claim 33, wherein the processing system is programmed to determine an average acceleration of the implement and programmed to compare the average acceleration to a predetermined value to determine the approximate level of surface polish.
37. The system of claim 33, wherein the processing system is programmed to determine an average velocity of the implement and programmed to compare the average velocity to a predetermined value to determine the approximate level of surface polish.
38. The system of claim 28, wherein the approximate level of surface polish corresponds to a target gloss level of the surface.
39. The system of claim 38, further comprising a handle and a stem positioned to couple the handle to the implement.

40. The system of claim 39, wherein the module includes a notification device coupled to the handle, and wherein the notification device is in communication with the processing system to notify a user when the target gloss level has been achieved.
41. The system of claim 40, wherein the notification device includes a visual notification.
42. The system of claim 40, wherein the notification device includes an audible notification.

1/6

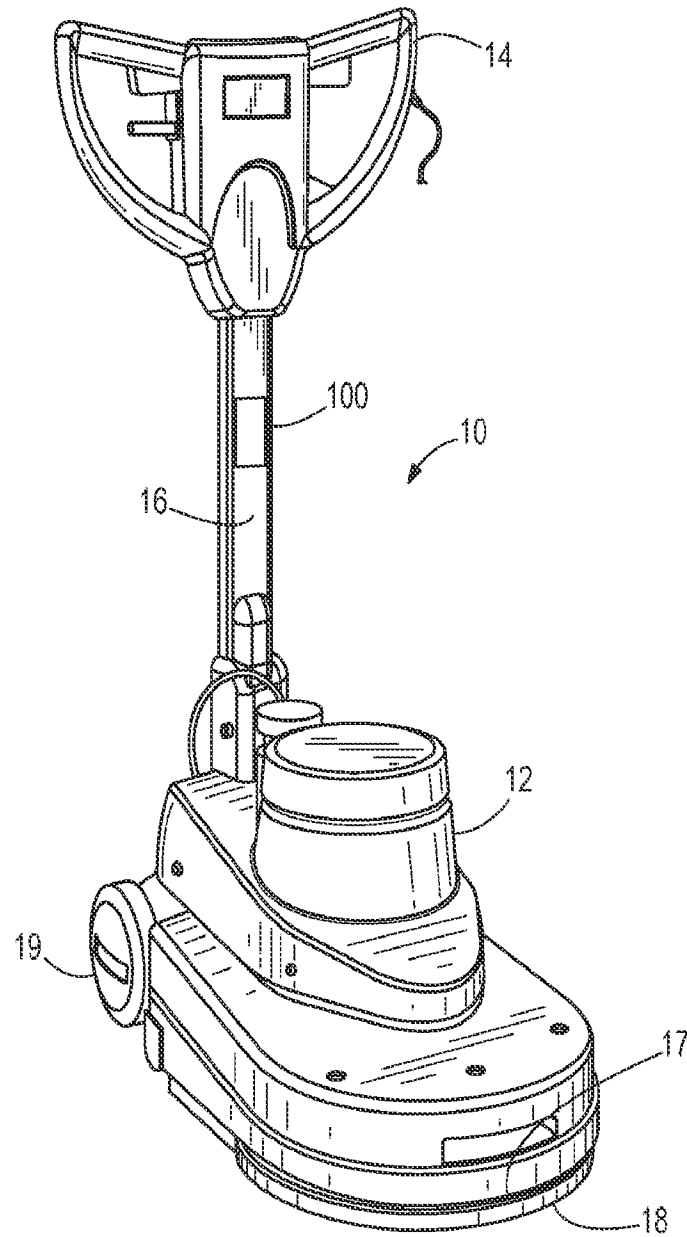


FIG. 1

2/6

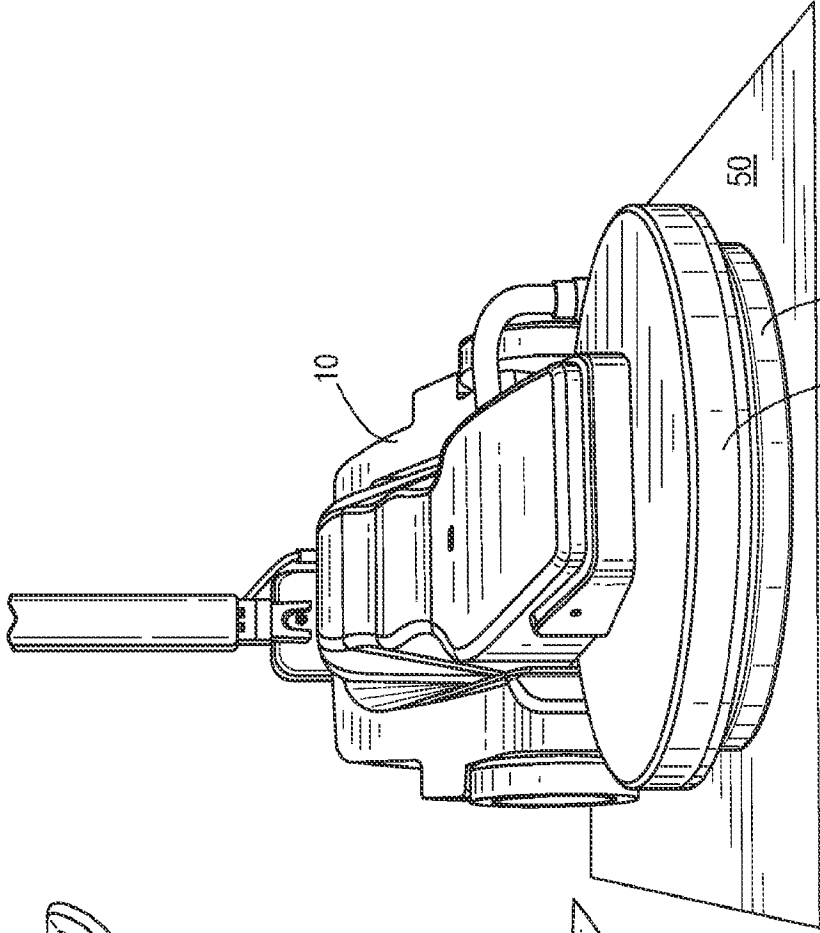


FIG. 3

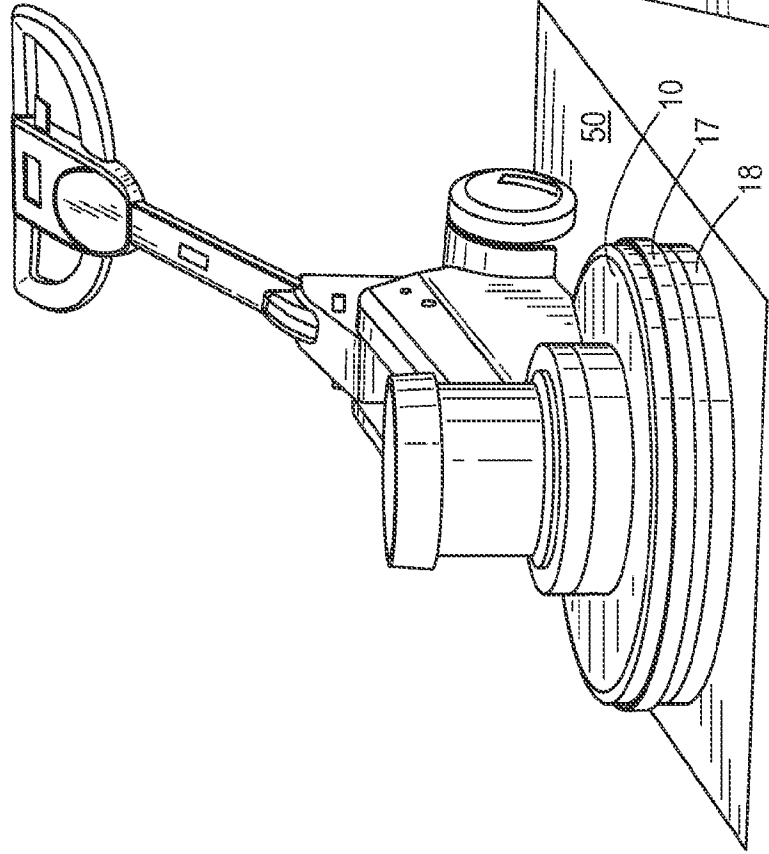
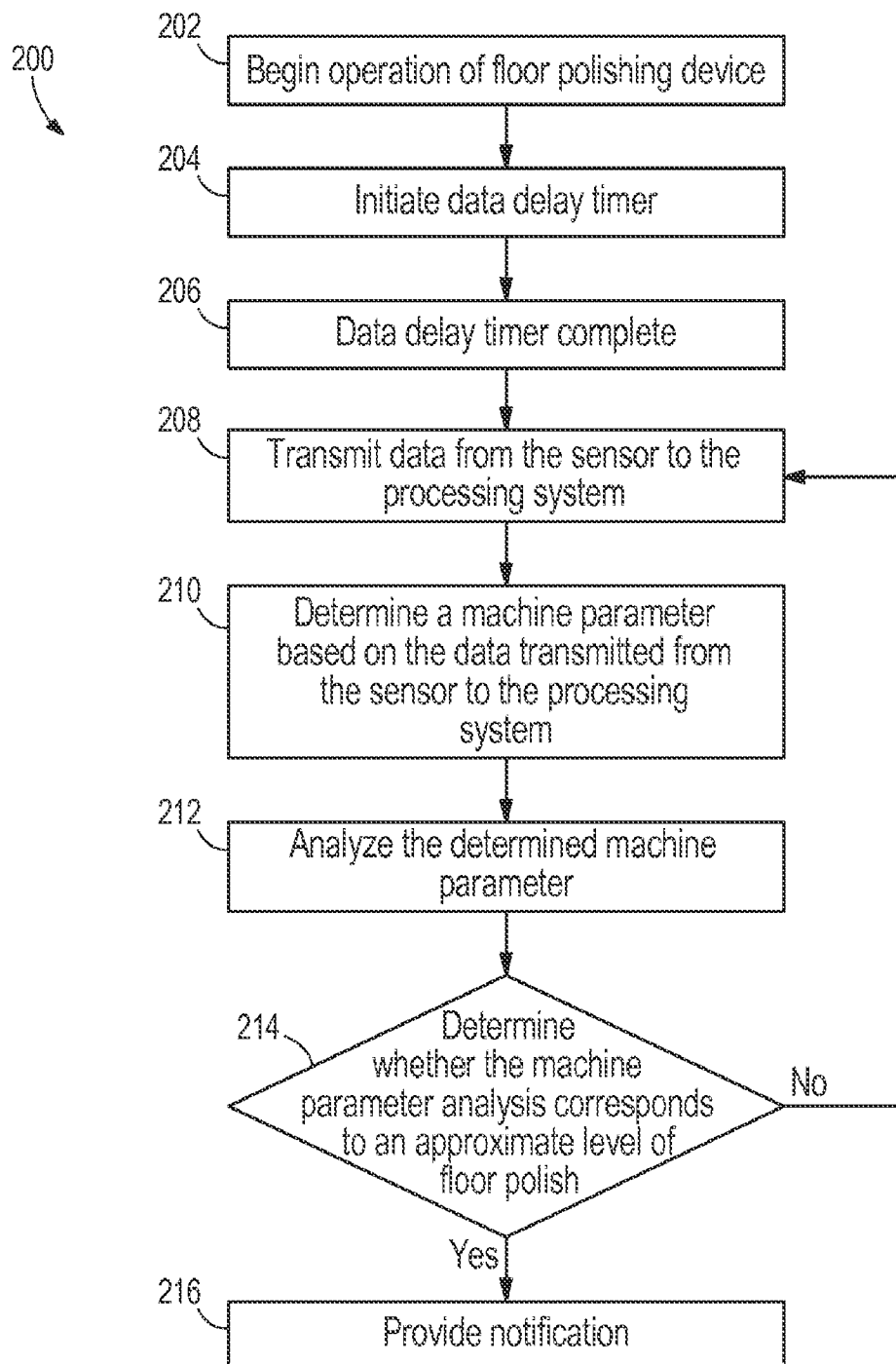
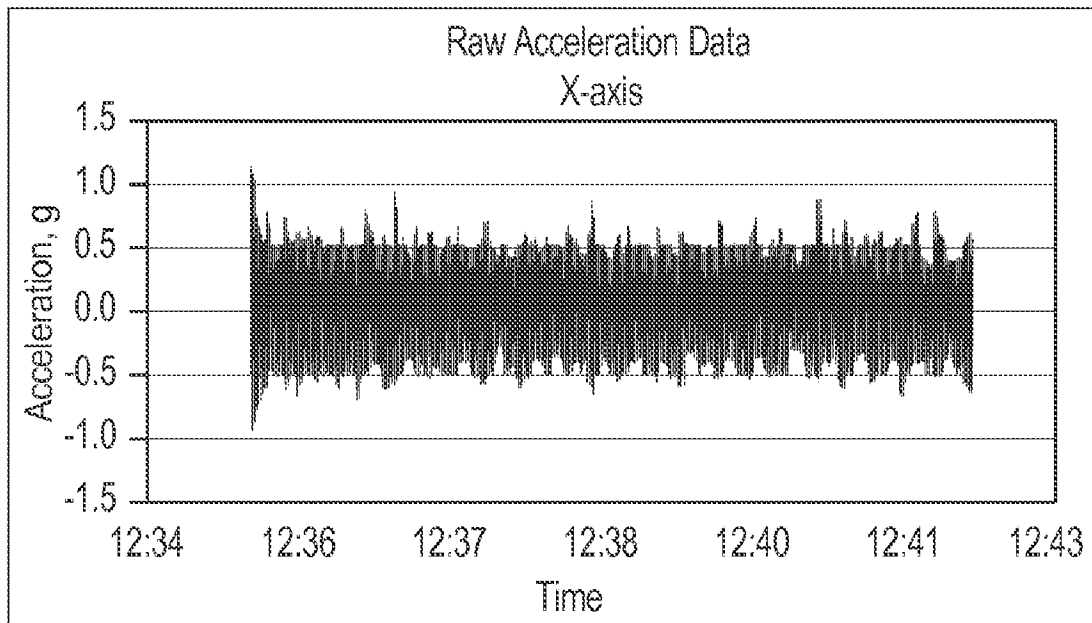
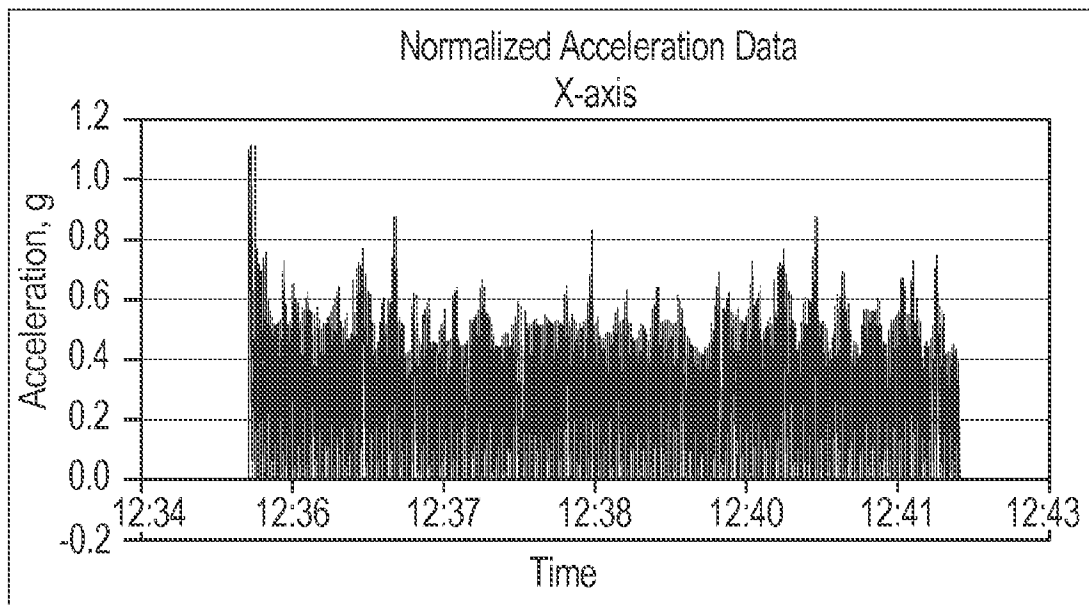


FIG. 2

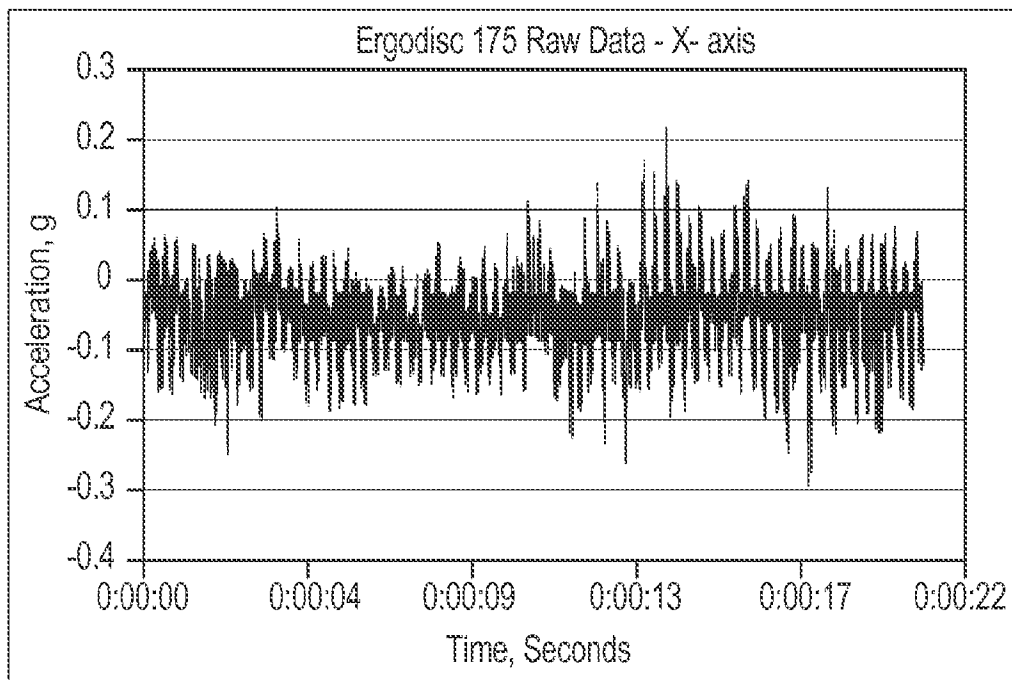
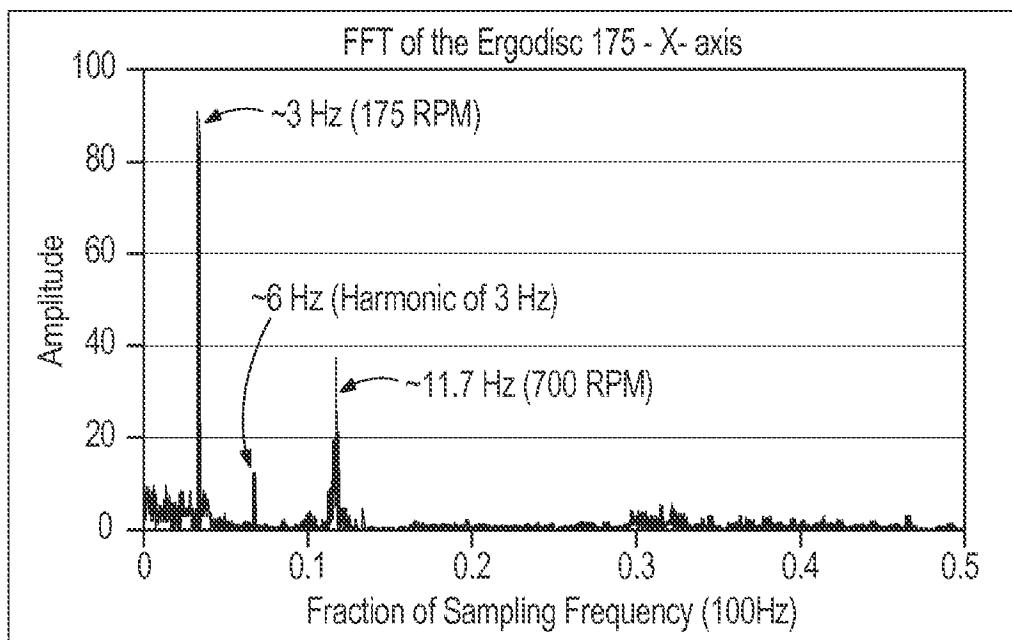
3/6

**FIG. 4**

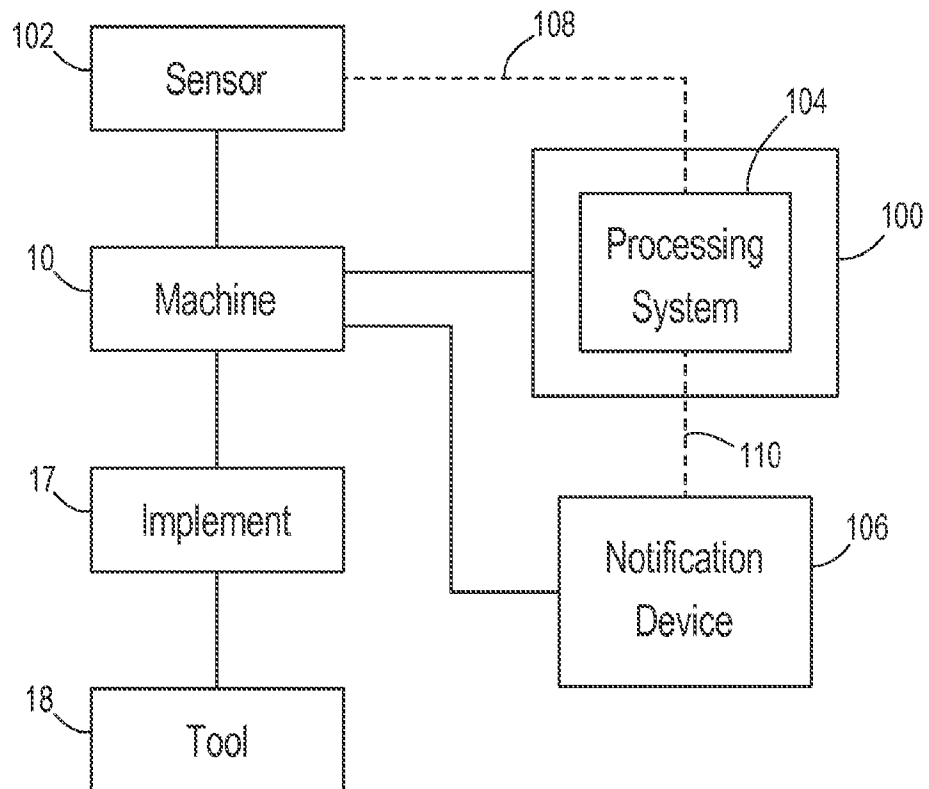
4/6

**FIG. 5****FIG. 6**

5/6

**FIG. 7****FIG. 8**

6/6

**FIG. 9**

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2015/037239

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A47L 11/16 (2015.01)

CPC - A47L 11/16 (2015.07)

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8) - A47L 11/00, 11/02, 11/08, 11/14, 11/16, 11/162, 11/164; B24B 51/00; G01B 5/28, 7/34, 21/30 (2015.01)

CPC - A47L 11/00, 11/02, 11/08, 11/14, 11/16, 11/162, 11/164; B24B 51/00; G01B 5/28, 7/34, 21/30 (2015.07) (keyword delimited)

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC - 15/49.1, 98; 73/105; 346/33F; 451/5, 6, 41, 66, 287; 700/1

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google, YouTube.

Search terms used: floor, polish, buff, detect, sense, sensor, measure, roughness, surface, Fourier, velocity, acceleration.

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2013/0044004 A1 (HWANG et al) 21 February 2013 (21.02.2013) entire document	1-11, 16-27
A	US 6,280,290 B1 (BIRANG et al) 28 August 2001 (28.08.2001) entire document	1-42
A	US 2009/0275264 A1 (SCHLICKER et al) 05 November 2009 (05.11.2009) entire document	1-42
A	US 6,626,029 B2 (DUNEGAN) 30 September 2003 (30.09.2003) entire document	1-42

☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

23 August 2015

Date of mailing of the international search report

14 SEP 2015

Name and mailing address of the ISA/

Mail Stop PCT, Attn: ISA/US, Commissioner for Patents

P.O. Box 1450, Alexandria, Virginia 22313-1450

Facsimile No. 571-273-8300

Authorized officer

Blaine Copenheaver

PCT Helpdesk: 571-272-4300

PCT OSP: 571-272-7774