

(51) International Patent Classification:
A61B 5/00 (2006.01)(21) International Application Number:
PCT/US2017/024000(22) International Filing Date:
24 March 2017 (24.03.2017)

(25) Filing Language: English

(26) Publication Language: English

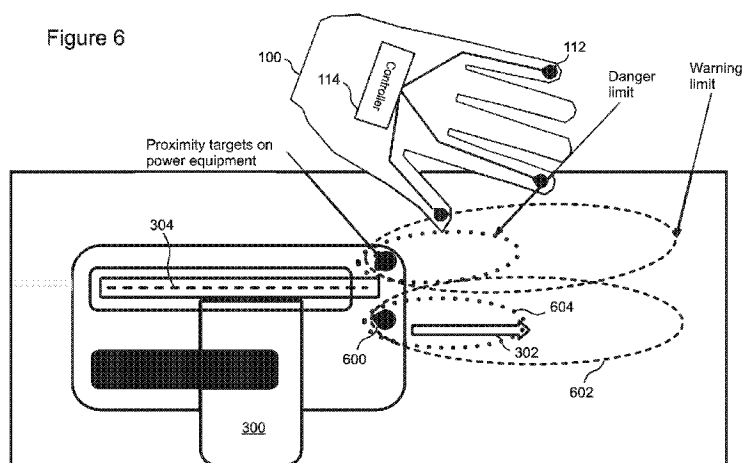
(30) Priority Data:
62/312,490 24 March 2016 (24.03.2016) US(71) Applicant: **WARWICK MILLS, INC.** [US/US]; 301
Turnpike Road, New Ipswich, New Hampshire 03071
(US).(72) Inventors: **HOWLAND, Charles A.**; Warwick Mills Inc.,
301 Turnpike Road, New Ipswich, New Hampshire 03071
(US). **HOWLAND, John C.**; Warwick Mills Inc., 301
Turnpike Road, New Ipswich, New Hampshire 03071
(US).(74) Agents: **BURUM, Douglas P** et al.; Maine Cernota &
Rardin, 547 Amherst St., 3rd Floor, Nashua, New Hamp-
shire 03063 (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, DJ, 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, KH, KN,
KP, KR, KW, 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).**Declarations under Rule 4.17:**

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
- as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))

Published:

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

(54) Title: WEARABLE SAFETY WARNING AND MEASUREMENT SYSTEM



(57) **Abstract:** An apparatus for protecting a power tool user includes a glove or other garment having a sensor that monitors proximity to the power tool. Glove embodiments can include finger or thumb proximity sensors, or sensors that detect hand position, finger or wrist joint angle, vibration, or acceleration. Sensing targets can be retroactively installed on the power tool, and can define warning or danger zones. Sensing can be via magnetic, electromagnetic, capacitive, eddy current, or range finding means. Sizes of warning or target areas can be controlled by selecting from a plurality of targets of various detection ranges. Protective responses can vary according to different sensed events, and can include audible, visual, or tactile alerts, or interruption of tool power. Embodiments can record proximity or status data during a work session for review, training, and certification. A controller can be physically cooperative with the garment.

WEARABLE SAFETY WARNING AND MEASUREMENT SYSTEM

Inventors:
Charles A. Howland
John C. Howland

RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Application No. 62/312,490, filed March 24, 2016, which is herein incorporated by reference in its entirety for all purposes.

FIELD OF THE INVENTION

[0002] The invention relates to power tool safety, and more particularly, to apparatus configured to enhance the safety of a user of power tools and to monitor the user's level of training.

BACKGROUND OF THE INVENTION

[0003] As portable and stationary power tools have become ubiquitous in manufacturing, construction and maintenance, so also have hand injuries that result from the use of power tools. Cut and puncture protective gloves, sleeves and aprons can be very effective against injuries arising from use of hand tools. However, the impact energies and strike rates of power tools are generally too high for personal protective equipment ("PPE") to be fully effective. Furthermore, in many cases, for example with rotary cutters and similar equipment, wearing of gloves and/or other PPE is not recommended, because some agencies feel that resulting snag and wind-up risks can make injuries more severe if such PPE becomes entangled in the rotary head.

[0004] One approach to reducing power tool injuries is to modify the power tools themselves in ways that reduce their risk. However, some users feel that

such modifications can tend to interfere with tool operation. In addition, such safety modifications can be expensive. In particular, it can be prohibitively expensive for a machine shop or factory to replace an existing inventory of existing power tools with new power tools that include active sensors and other safety modifications and devices.

[0005] There is also a lack of standards for such safety devices and modifications, making it extremely unlikely that safety modifications would be consistent across an inventory of power tools purchased from multiple suppliers. As a result, such safety modifications and devices, if implemented on a full inventory of power tools, can impose a significant additional training burden on a machine shop or factory, in that users of the power tools must be trained in the operation of the safety features of each power tool, as well as in use of the tool itself.

[0006] What is needed, therefore, is an apparatus for protecting the hands of a power tool operator without imposing an undue cost and training burden on the owner of the power tool.

SUMMARY OF THE INVENTION

[0007] The present invention is an apparatus for protecting the hands of a power tool operator without imposing an undue cost and training burden on the owner of the power tool. The invention takes advantage of the fact that the key issue in protecting users from power equipment is training. When users are fully trained, they consistently keep their hands out of danger zones when using power tools. Conversely, the risk of injury is always greatest when new operators are being trained.

[0008] Accordingly, the present invention is an apparatus and method that protects the hands of a power tool operator while assisting in the operator's training. Embodiments of the disclosed apparatus can be adapted to existing power tools, further reducing the cost and providing for uniformity of the safety

features across a full range of different power tools supplied by different manufacturers.

[0009] Specifically, the disclosed apparatus includes a garment with one or more integrated sensors, at least one target that is attached or attachable to a power tool and is detectable by the sensor, and a controller that monitors proximity of the sensor to the target and initiates a protective response when the sensor proximity is determined to be closer than a specified threshold distance. In various embodiments, the protective response can include one or more of an auditory, visual, and/or tactile alert (such as a vibrating device located near the sensor). In embodiments, the protective response includes cutting power to the power tool.

[0010] In embodiments, the garment further includes sensors that monitor directional and angular positional features of the user's body, accelerating movements of the user's body, and/or vibrations to which the user's body is subjected. Embodiments record and save measurements of position, movement, acceleration, linear and angular position, and vibration for later analysis, evaluation, certification, and training.

[0011] In embodiments, the disclosed garment is a glove that includes a set of sensors distributed over the hand(s) and fingers for measurement of tool proximity, finger and wrist joint angle, and hand and finger movement and acceleration. The disclosed glove system enables measurement of hand and finger proximity to blades and/or other dangerous elements of power tools.

[0012] In various embodiments, the garment is fashioned from a "smart textile," wherein the sensor or sensors are attached to the fabric or embedded within the fabric, and the interconnections between the sensor or sensors and the controller are provided by conductors that are integral with the fabric.

[0013] Embodiments of the invention enable the predefinition of danger and/or warning zones surrounding dangerous elements of a power tool. In some of these

embodiments, the warning and danger zones are delimited by placement of targets at selected locations surrounding the dangerous elements. In various embodiments, a plurality of different types of target are provided, so as to enhance the ability of the sensor(s) to determine positional information relative to the power tool and defined zones. Some embodiments further enable specification of appropriate protective responses depending on the nature of an alert. For example, in embodiments a perceptible warning such as an audible alarm is initiated when a glove sensor enters a defined warning zone, while the power to the tool is cut off if the sensor enters a defined danger zone.

[0014] In some embodiments, the controller is attached to or integral with the glove or other garment. In other embodiments, the controller is a separate unit. Communication between the sensor(s), controller, alert-generating devices, data logging units, and/or the power supply of the power tool can be by any combination of wired and wireless means known in the art, including Bluetooth and USB connections.

[0015] It will be understood by one of skill in the art that while much of the present disclosure is described with reference to a glove, the disclosure applies equally to other parts of a user's body, such as a foot, elbow, or knee, that interact with or otherwise are subject to coming into contact with dangerous aspects of a power tool. In such cases a shoe, elbow pad, knee pad, etc. is substituted in place of the glove described herein.

[0016] A first general aspect of the present invention is an apparatus for enhancing safety of a power equipment user. The apparatus includes a garment, at least one proximity measurement sensor cooperative with the garment, a control system in communication with the proximity measurement sensor, and a responding system cooperative with the control system and configured to provide a protective response when specified conditions are detected by the control system based on measurements made by the at least one proximity measurement sensor.

[0017] In embodiments, the protective response includes a warning signal that is perceptible to the power equipment user.

[0018] In some of these embodiments, the perceptible warning signal includes at least one of a visible warning signal, an audible warning signal, and a vibrational warning signal.

[0019] In any of the above embodiments, the protective response can include terminating delivery of power to the power equipment.

[0020] Any of the above embodiments can further include a logging system configured to log data obtained by the apparatus.

[0021] In any of the above embodiments, the garment can include a piezo thin film laminate sensor and/or a piezo fiber strain sensor.

[0022] In any of the above embodiments, the garment can be a glove, and the at least one proximity measurement sensor can include a sensor that is cooperative with a fingertip of the user. Some of these embodiments include sensors that are cooperative with an index finger of the user, a smallest figure of the user, and a thumb of the user.

[0023] In any of the above embodiments, the at least one proximity measurement sensor can be configured to sense at least one of a magnetic field and an eddy current.

[0024] In any of the above embodiments, the at least one proximity measurement sensor can be at least one of capacitive and inductive.

[0025] In any of the above embodiments, the at least one proximity measurement sensor can be a range finding sensor.

[0026] In any of the above embodiments, the at least one proximity measurement sensor can be configured to measure an electromagnetic spectrum.

[0027] Any of the above embodiments can further include a target that is cooperative with the power equipment and can be sensed by the at least one proximity measurement sensor. Some of these embodiments include a plurality of targets that can be selected so as to define at least one of a warning region and a danger region associated with the power equipment. In any of these embodiments, the target or targets can be configured for retrofit attachment to the power equipment.

[0028] Any of the above embodiments can further include a status sensor that is configured to measure at least one of position, angular joint configuration, acceleration, and vibration.

[0029] And in any of the above embodiments, the control system can be physically cooperative with the garment.

[0030] A second general aspect of the present invention is a garment that includes a sensor and a logging system that is in data communication with the sensor, the sensor and data system being configured to record data pertaining to at least one of proximity of said garment to a designated location, a skin temperature of a user, a finger angle of the user, and a wrist joint angle of the user.

[0031] In any of the above embodiments, the logging system can be configured to execute an algorithm that permits subsequent display of the recorded data. And in some of these embodiments, the algorithm permits subsequent display of the recorded data as a function of time.

[0032] A third general aspect of the present invention is a garment configured for wearing by a user, the garment comprising a sensing system and a responding system, the responding system being configured to provide at least one of an optical signal to the user, a vibrational signal to the user, an acoustic signal to the user, and an electrical signal to the equipment.

[0033] A fourth general aspect of the present invention is a sensing system and a garment controller in communication with an external power equipment control

system, said garment controller being configured to deactivate said power equipment according to measurements made by the sensing system.

[0034] In embodiments, the garment controller is in wireless communication with the external control system. In some of these embodiments, the wireless communication is Bluetooth communication.

[0035] In any of the above embodiments, the garment controller can be in wired communication with the external control system.

[0036] And in any of the above embodiments, the garment can be controlled by a control panel that is attached to the garment.

[0037] The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the drawings, specification, and claims. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF THE DRAWINGS

[0038] Figure 1 is a block diagram illustrating an embodiment of the present invention;

[0039] Figure 2A illustrates the definition of a hand axis included in a coordinate system that is used to describe embodiments of the present invention;

[0040] Figure 2B illustrates the definition of a tool axis included in a coordinate system that is used to describe embodiments of the present invention;

[0041] Figure 2C illustrates the definition of an angle between the hand axis and the tool axis in a coordinate system that is used to describe embodiments of the present invention;

[0042] Figure 3A illustrates the most likely work-piece hand alignment relative to power equipment of a right hand dominant user;

[0043] Figure 3B illustrates the least likely work-piece hand alignment relative to power equipment of a right hand dominant user;

[0044] Figure 3C illustrates the most likely work-piece hand alignment relative to power equipment of a left hand dominant user;

[0045] Figure 4A is a side view of the most likely work-piece hand position when in an overhand grip on the work-piece;

[0046] Figure 4B is an end view of the position of Figure 4A;

[0047] Figure 4C is a side view of the second most likely work-piece hand position when in an underhand grip on the work-piece;

[0048] Figure 4D is an end view of the position of Figure 4C;

[0049] Figure 5A illustrates the most likely work-piece hand alignment to a stationary power tool;

[0050] Figure 5B illustrates the second most likely work-piece hand alignment to a stationary power tool; and

[0051] Figure 6 illustrates interaction between sensors in fingertips of a glove and proximity targets located on power equipment.

DETAILED DESCRIPTION

Proximity Sensing Mode

[0052] As noted above, the present invention is an apparatus for protecting the hands (or other body parts) of a power tool operator. Embodiments reduce the cost to a machine shop or other multi-tool facility by taking advantage of the fact that the key issue in protecting users from power equipment is training.

Accordingly, embodiments of the disclosed apparatus provide features that directly assist with training, evaluating, and certifying new users of power tools, such that extraordinary safety devices and modifications need not be implemented on power tools that are only used by experienced operators.

[0053] Furthermore, embodiments of the present invention can be adapted to existing power tools, further reducing the cost and providing for uniformity of the safety features across a full range of different power tools supplied by different manufacturers. Some of these embodiments require only that passive modifications be applied to existing power tools. Such modifications can be simple for users to make and enable the retrofitting of power tools that have already been purchased. In embodiments, these passive modifications include the mounting by users on the power equipment of magnetic, optical, and/or capacitive targets that can be selected from a set of targets supplied with the disclosed system. The mounting can be adhesive or via any attachment means known in the art.

[0054] With reference to Figure 1, in embodiments the disclosed apparatus of the present invention includes a wearable glove 100 or other garment that includes at least one sensor 112 and a controller 114. In the embodiments of Figure 1, the controller 114 is attached to the glove 100, while in similar embodiments the controller is separate from the garment 100 and in wired or wireless communication therewith.

[0055] In embodiments, the controller 114 includes the following five functional elements:

- 1) a sensor interface unit 102;
- 2) a value limit comparison unit and data logger 104;
- 3) a user alarm module 106;
- 4) an external communication unit 108; and
- 5) a wireless data link 110.

[0056] In some embodiments, all of these functional elements are provided by a single microprocessor-based machine controller 114. In various embodiments, the sensor interface unit 102 is designed to interface with redundant sensors that reduce the potential for a false negative result. In these embodiments, the risk of a false positive is very low, because the only action taken by the system in the case of a false alert is to issue a perceptible warning and/or shut down the power equipment. This is in contrast to some integrated safety systems of the prior art that use a high speed actuator to stop a blade or tool cutter, such that a false safety alert can damage the equipment such that it must be repaired, and a new cutter must be mounted, before the equipment can be used again. Accordingly, because the penalty incurred as a result of a false safety alert is only a small loss in productivity, embodiments of the present invention bias sensor and value limit comparison thresholds to be conservative, thereby limiting risk to the operator.

Work Piece Hand Axis and Tool and Workpiece Axis of Travel

[0057] With reference to Figures 2A through 2C, a coordinate system for the description of the axis of a hand 200 and a sensor axis 202 are defined. This reference frame is used herein to describe the geometry of embodiments of glove sensors 112, including their sensitivity and the corresponding target sensitivity. As shown in Figure 2C, the angle 204 referred to in the following description is taken from the small finger side of the glove 100 to the tool or work piece axis.

Proximity Sensor Alignment to Tool or Workpiece Travel direction

[0058] As can be seen from Figures 3A and 3C, the most likely alignment of hand 100 closest to a work-piece 300 is approximately perpendicular to the direction of travel 302 of the power tool 302. With reference to Figure 3B, as the alignment of the work-piece hand 100 goes beyond 90 degrees to the direction of travel 300, this results in upper arm and shoulder strain for the operator, so this configuration is not very likely. In embodiments, the sensitivity direction of the proximity sensors 112 is aligned approximately 80 degrees from perpendicular to

the hand axis 200. This configuration maximizes the signal in the most likely work-piece hand alignments relative to the direction of tool travel 300.

Thumb and Small Finger Sensing Configurations

[0059] With reference to Figure 4A, in many cases when an accident does occur, the most likely affected parts of the hand 100 are the thumb 400 and index finger 402. Accordingly, in the embodiment of Figure 4A, sensors 112 are included only in these two locations. With reference to Figure 4B, the small finger 404 is at risk only in the less likely, underhand work holding position. Accordingly, in the embodiment of Figure 4B, the sensors 112 are distributed only in the thumb, index, and small finger regions to protect the work-piece hand in the underhand work holding position.

Stationary Power Tool Proximity Configurations

[0060] With reference to Figures 5A and 5B, in some embodiments the sensitivity directions of the sensors 112 in the gloves 100 are configured to include 45 degree alignment 204 between the hand axis 200 and the direction of travel 302.

Proximity Sensors

[0061] With reference to Figure 6, in certain embodiments the system of the present invention makes use of magneto-inductive sensors (MIS) 112 and interchangeable, permanent magnet targets 600. Some of these embodiments provide target magnets 600 that are interchangeable on the power equipment. In embodiments, a magnet set is selected from among a group of magnet sets according to the size and configuration of the power tool, the level of experience of the user, and other factors, wherein each magnet set provides a different combination of magnet strengths. This allows the strengths of the magnetic fields, and hence the sensing distance from the glove sensor 112 to the equipment 600, to be changed simply by changing to a different set of magnets.

[0062] This approach makes it easy to adjust warning 602 and danger 604 standoff distances simple by exchanging the magnetic targets 600. Accordingly, in these embodiments there is often no need to adjust the sensing limits in the value limit comparison unit 104. Instead, the user makes these changes simply by exchanging the magnetic targets 600.

Safety Control Mode

[0063] For some institutions and companies the desired mode for safety is to require the use of safety gloves 100 during operation of power equipment. To support this operating mode, embodiments of the present invention include lockable plugin bases for all the controlled equipment. The lockable plugin bases are configured such that when they are present, the power to the equipment is not enabled unless the safety gloves 100 are worn. In certain of these embodiments, the proximity sensing is in place and continues to shut off power when the hands are found to be in the danger zone 604.

Vibration Measurement

[0064] Embodiments of the present invention combine measurement of power tool proximity with sensing of induced vibration in the hands from the power tool. Hand Arm Vibration Syndrome, or “HAVS,” is considered to be an occupational injury, and so it can be desirable to accumulate data that documents the actual vibration exposure and durations experienced by a power tool user. Accordingly, embodiments of the present invention are able to alert the user when preset vibration limits are exceeded.

[0065] Both the warning to the user and the accumulated vibration data can be useful in modifying behavior to help configure the work environment to produce safer, lower vibration impact to the user’s hands. The starting point for these limit values is the British HSE values of 2.5m/sec² warning limit and 5m/sec² damage limit. The data logging function in some of these embodiments is also useful in allowing the employer to audit and document the vibration impact from a task. In some embodiments, the measurements made by the system are modeled after

ANSI 2.70 and ISO53491 2001, which can be found at <https://www.aiha.org/LocalSections/html/florida/AIHA%20FL%200509%20rev1C.pdf>, incorporated herein by reference for all purposes.

Repetitive Motion and Forces and Impact Measurement

[0066] Embodiments include motion and acceleration sensors that can be used to monitor and warn against injury due to repetitive motions, forces, and impacts. The measured data can be compared with established criteria, such as the US CDC criteria that can be found at <http://www.cdc.gov/niosh/docs/97141/pdfs/97141e.pdf>, which is incorporated herein by reference for all purposes.

Training Mode

[0067] With reference again to Figure 1, in embodiments of the present invention, in addition to providing warnings to the user and power interruptions in response to proximity of the sensors to the danger zone 604 of the equipment, the on-garment controller 114 also logs data over a session, and this data is provided to an external display and analysis system such as a smart phone 116 or computer. In various embodiments, the analysis system 116 includes a data base structure 118 that logs user names, start and end times for a session, as well as the type of task, work cell, and or equipment types the user was operating during the data collection session. This data can then be used by employers and/or school personnel to evaluate the level of proficiency of the user. In embodiments, the data includes the number of events where the user's hands were in the warning area 602, and the number of events when the user's hands were in the danger zone 604, causing the equipment power to be cut.

[0068] Embodiments include a vibration mode, in which the magnitudes and durations of exposure of the user's hands to vibrations are recorded.

[0069] Various embodiments include a joint angle and impact mode, in which flex events are logged and the number of over-flex events and hyper-flex events are logged.

[0070] Certain embodiments include a productivity mode, in which the flex and vibration patterns are logged, so that by using pattern learning or other forms of pattern recognition the total number of relevant events can be determined. Deviation from the ideal task flex and vibration patterns can be assessed, and data-driven training can be used to help operators improve safety and performance.

[0071] Various embodiments include an analysis function that permits a school or employer to set criteria for maximum numbers and types of incursions into warning zones 602 and danger zones 604 that are allowed for safe qualification of an operator on a task that requires use of a piece of equipment or work cell. In such instances, the operating data provided by embodiments of the present invention can be very useful for schools and/or employers who need evidence that training has been effective.

[0072] The use of the training mode in embodiments integrates very well with behavioral safety programs. For example, when new operators have used the data logging system 118 over enough sessions to demonstrate that they have internalized the safe working positions for their hands, the operator can be qualified on the task. After that, the training mode need only be used again for periodic audits of operator behavior.

[0073] The foregoing description of the embodiments of the invention has been presented for the purposes of illustration and description. Each and every page of this submission, and all contents thereon, however characterized, identified, or numbered, is considered a substantive part of this application for all purposes, irrespective of form or placement within the application.

[0074] This specification is not intended to be exhaustive. Although the present application is shown in a limited number of forms, the scope of the

invention is not limited to just these forms, but is amenable to various changes and modifications without departing from the spirit thereof. One of ordinary skill in the art should appreciate after learning the teachings related to the claimed subject matter contained in the foregoing description that many modifications and variations are possible in light of this disclosure. Accordingly, the claimed subject matter includes any combination of the above-described elements in all possible variations thereof, unless otherwise indicated herein or otherwise clearly contradicted by context. In particular, the limitations presented in dependent claims below can be combined with their corresponding independent claims in any number and in any order without departing from the scope of this disclosure, unless the dependent claims are logically incompatible with each other.

CLAIMS

I claim:

- 1 1. An apparatus for enhancing safety of a power equipment user, the apparatus
2 comprising:
3 a garment;
4 at least one proximity measurement sensor cooperative with the garment;
5 a control system in communication with the proximity measurement sensor;
6 and
7 a responding system cooperative with the control system and configured to
8 provide a protective response when specified conditions are detected by the
9 control system based on measurements made by the at least one proximity
10 measurement sensor.
- 1 2. The apparatus of claim 1, wherein the protective response includes a
2 warning signal that is perceptible to the power equipment user.
- 1 3. The apparatus of claim 2, wherein the perceptible warning signal includes
2 at least one of:
3 a visible warning signal;
4 an audible warning signal; and
5 a vibrational warning signal.
- 1 4. The apparatus of claim 1, wherein the protective response includes
2 terminating delivery of power to the power equipment.
- 1 5. The apparatus of claim 1, further comprising a logging system configured
2 to log data obtained by the apparatus.
- 1 6. The apparatus of claim 1, wherein the garment includes a piezo thin film
2 laminate sensor;
- 1 7. The apparatus of claim 1, wherein the garment includes a piezo fiber strain
2 sensor.

1 8. The apparatus of claim 1, wherein the garment is a glove, and the at least
2 one proximity measurement sensor includes a sensor that is cooperative with a
3 fingertip of the user.

1 9. The apparatus of claim 1, wherein the garment is a glove, and the at least
2 one proximity measurement sensor includes:

3 a sensor that is cooperative with an index finger of the user;

4 a sensor that is cooperative with a smallest finger of the user; and

5 a sensor that is cooperative with a thumb of the user.

1 10. The apparatus of claim 1, wherein the at least one proximity measurement
2 sensor is configured to sense at least one of a magnetic field and an eddy current.

1 11. The apparatus of claim 1, wherein the at least one proximity measurement
2 sensor is at least one of capacitive and inductive.

1 12. The apparatus of claim 1, wherein the at least one proximity measurement
2 sensor is a range finding sensor.

1 13. The apparatus of claim 1, wherein the at least one proximity measurement
2 sensor is configured to measure an electromagnetic spectrum.

1 14. The apparatus of claim 1, further comprising a target that is cooperative
2 with the power equipment and can be sensed by the at least one proximity
3 measurement sensor.

1 15. The apparatus of claim 14, wherein the apparatus comprises a plurality of
2 targets that can be selected so as to define at least one of a warning region and a
3 danger region associated with the power equipment.

1 16. The apparatus of claim 14, wherein the target is configured for retrofit
2 attachment to the power equipment.

1 17. The apparatus of claim 1, further comprising a status sensor that is
2 configured to measure at least one of position, angular joint configuration,
3 acceleration, and vibration.

1 18. The apparatus of claim 1, wherein the control system is physically
2 cooperative with the garment.

1 19. A garment comprising a sensor and a logging system that is in data
2 communication with the sensor, the sensor and data system being configured to
3 record data pertaining to at least one of:

- 4 proximity of said garment to a designated location;
- 5 a skin temperature of a user;
- 6 a finger angle of the user; and
- 7 a wrist joint angle of the user.

1 20. The garment of claim 19, wherein the logging system is configured to
2 execute an algorithm that permits subsequent display of the recorded data.

1 21. The garment of claim 20, wherein the algorithm permits subsequent display
2 of the recorded data as a function of time.

1 22. A garment configured for wearing by a user, the garment comprising a
2 sensing system and a responding system, the responding system being configured
3 to provide at least one of an optical signal to the user, a vibrational signal to the
4 user, an acoustic signal to the user, and an electrical signal to the equipment.

1 23. A garment comprising a sensing system and a garment controller in
2 communication with an external power equipment control system, said garment
3 controller being configured to deactivate said power equipment according to
4 measurements made by the sensing system.

1 24. The garment of claim 23, wherein the garment controller is in wireless
2 communication with the external control system.

1 25. The garment of claim 24, wherein the wireless communication is Bluetooth
2 communication.

1 26. The garment of claim 23, wherein the garment controller is in wired
2 communication with the external control system.

1 27. The garment of claim 23, wherein the garment is controlled by a control
2 panel that is attached to the garment.

1/6

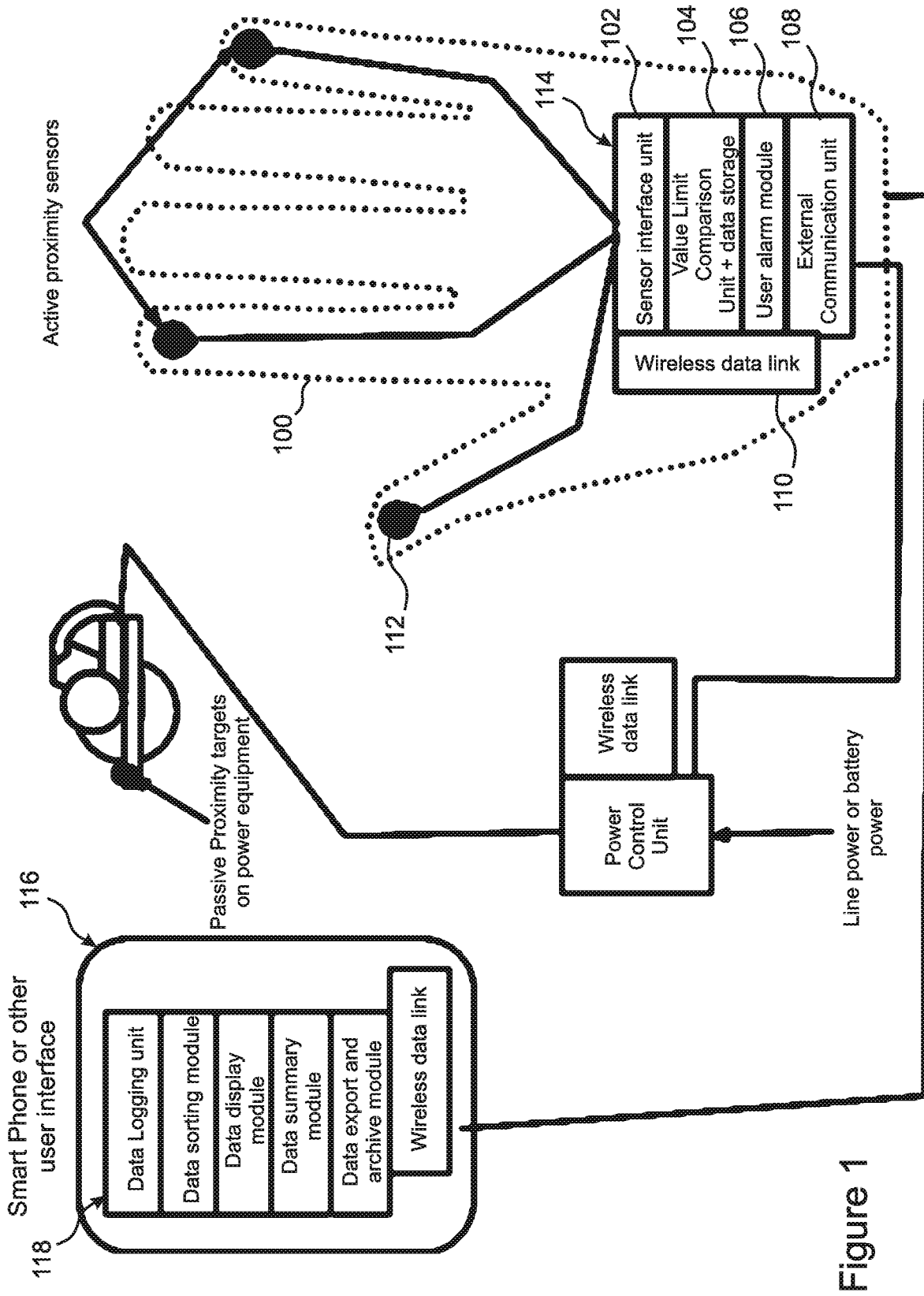


Figure 1

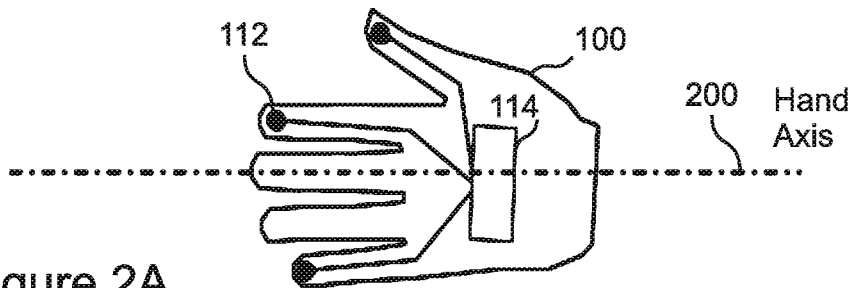


Figure 2A

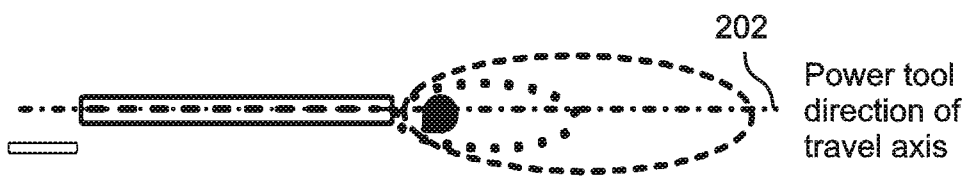


Figure 2B

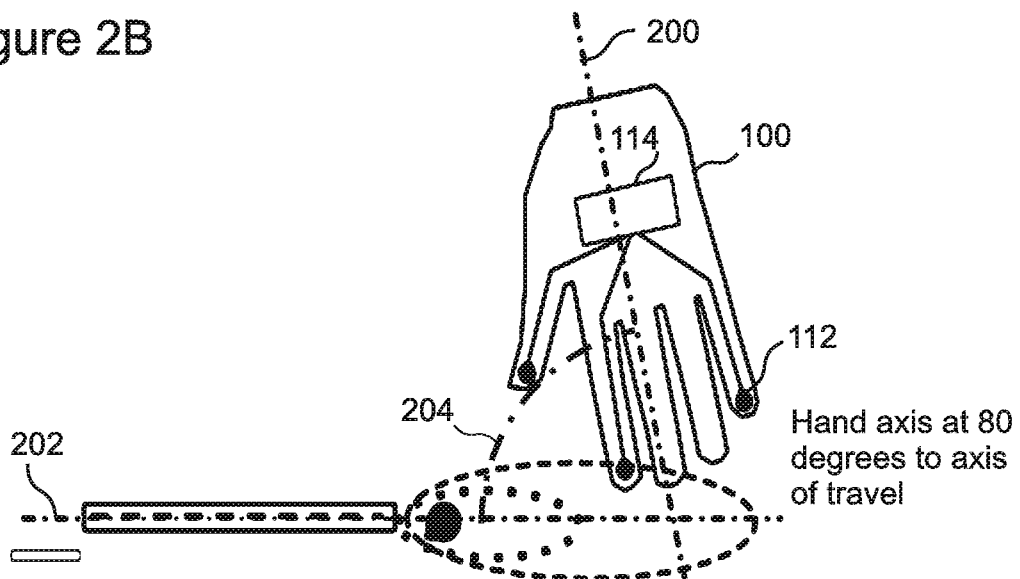


Figure 2C

Most likely work-piece
hand alignment of right
hand dominant users

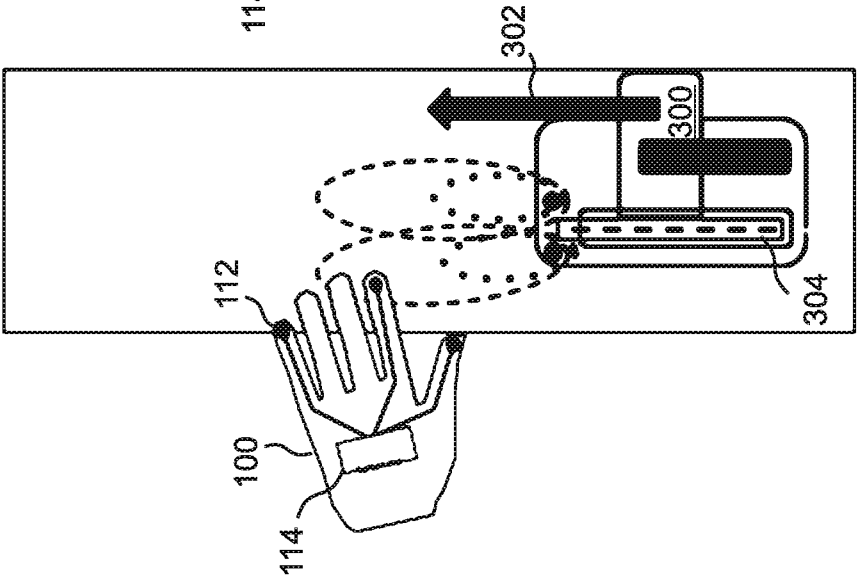


Figure 3A

Least likely work-piece
hand alignment (right
hand dominant)

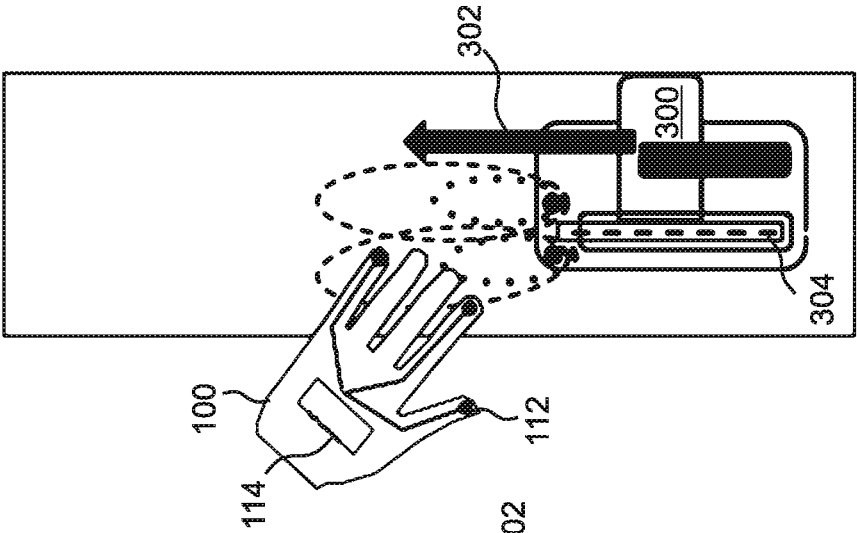


Figure 3B

Most likely work-piece
hand alignment of left
hand dominant users

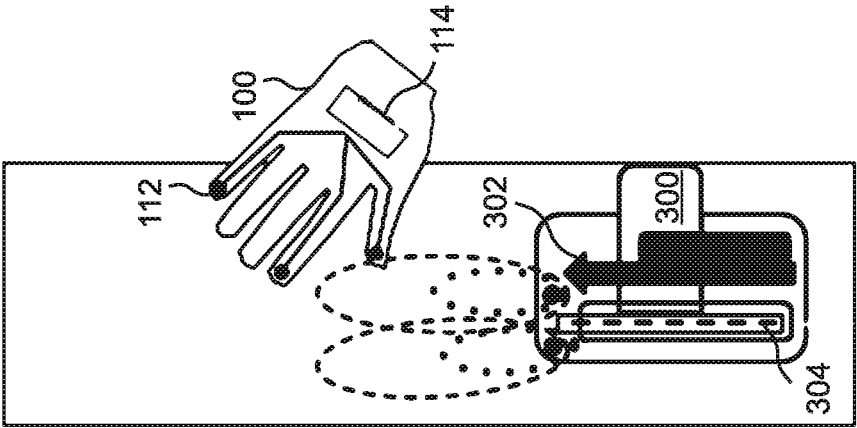


Figure 3C

Second most likely work-piece hand with underhand grip on work-piece. Exposes small finger to cutter

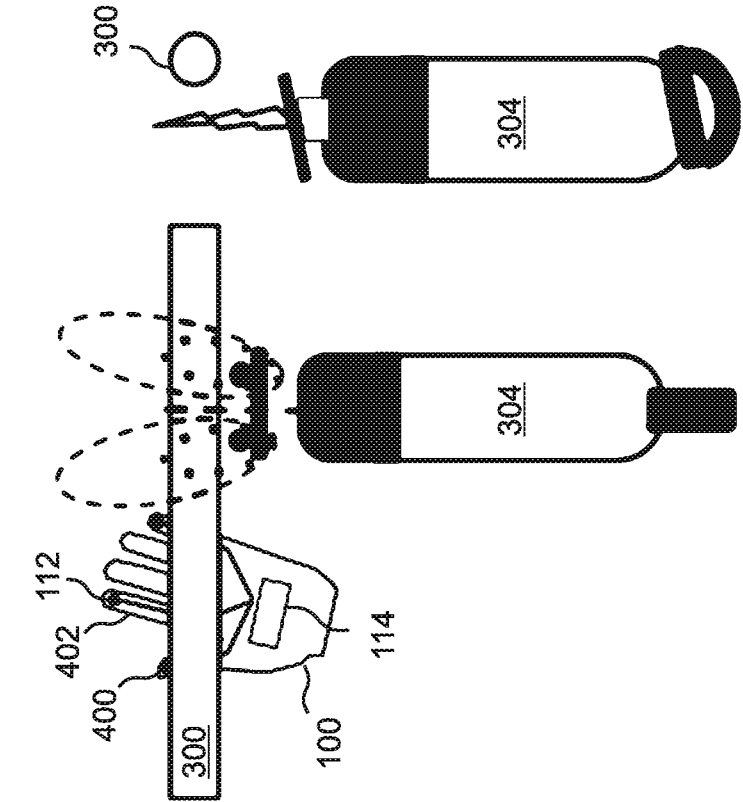


Figure 4D

Most likely work-piece hand with overhand grip on work-piece. Exposes thumb and index to cutter

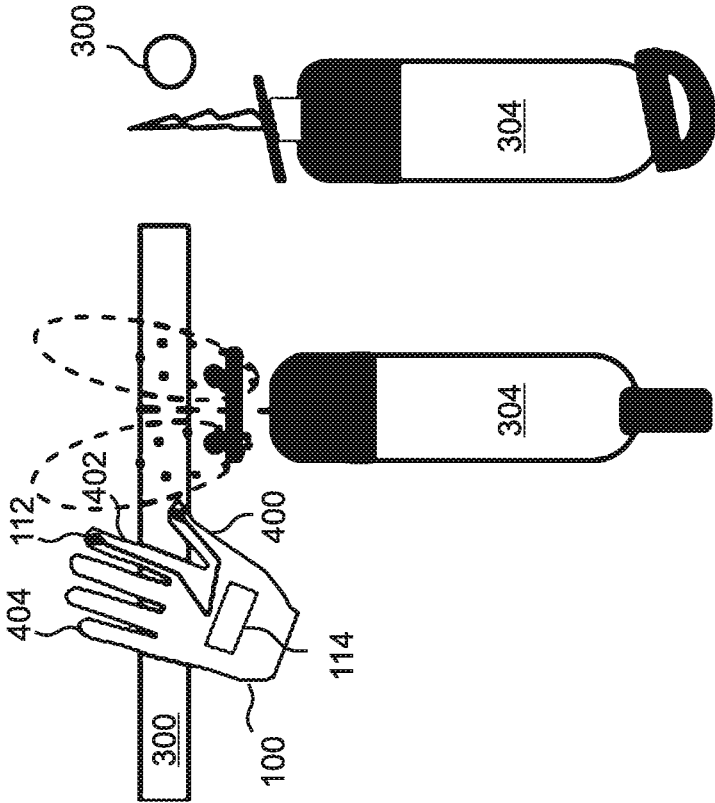


Figure 4B

Figure 4C

Figure 4A

Most likely work-piece hand alignment to stationary power tool. Risk is highest to thumb and index with target aligned parallel to workpiece travel.

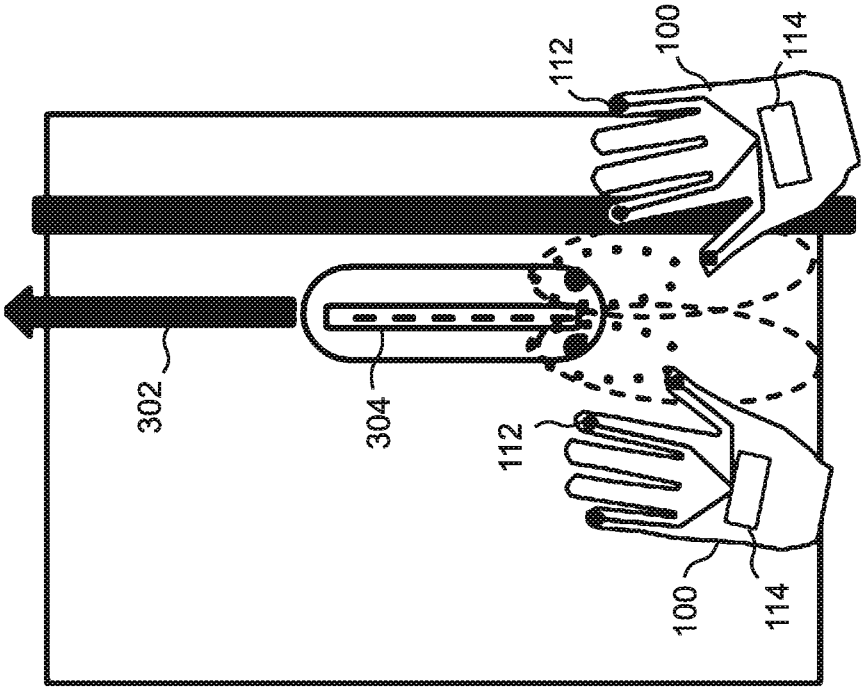


Figure 5A

Second most likely work-piece hand alignment to stationary power tool. Risk is highest to small finger and index with targets aligned approximately 45 degrees to workpiece travel.

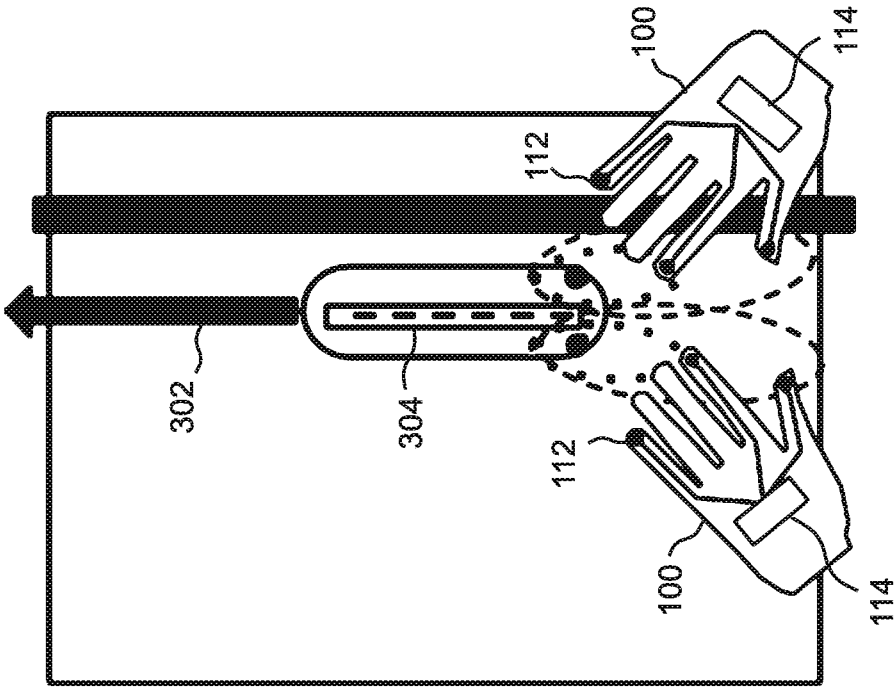
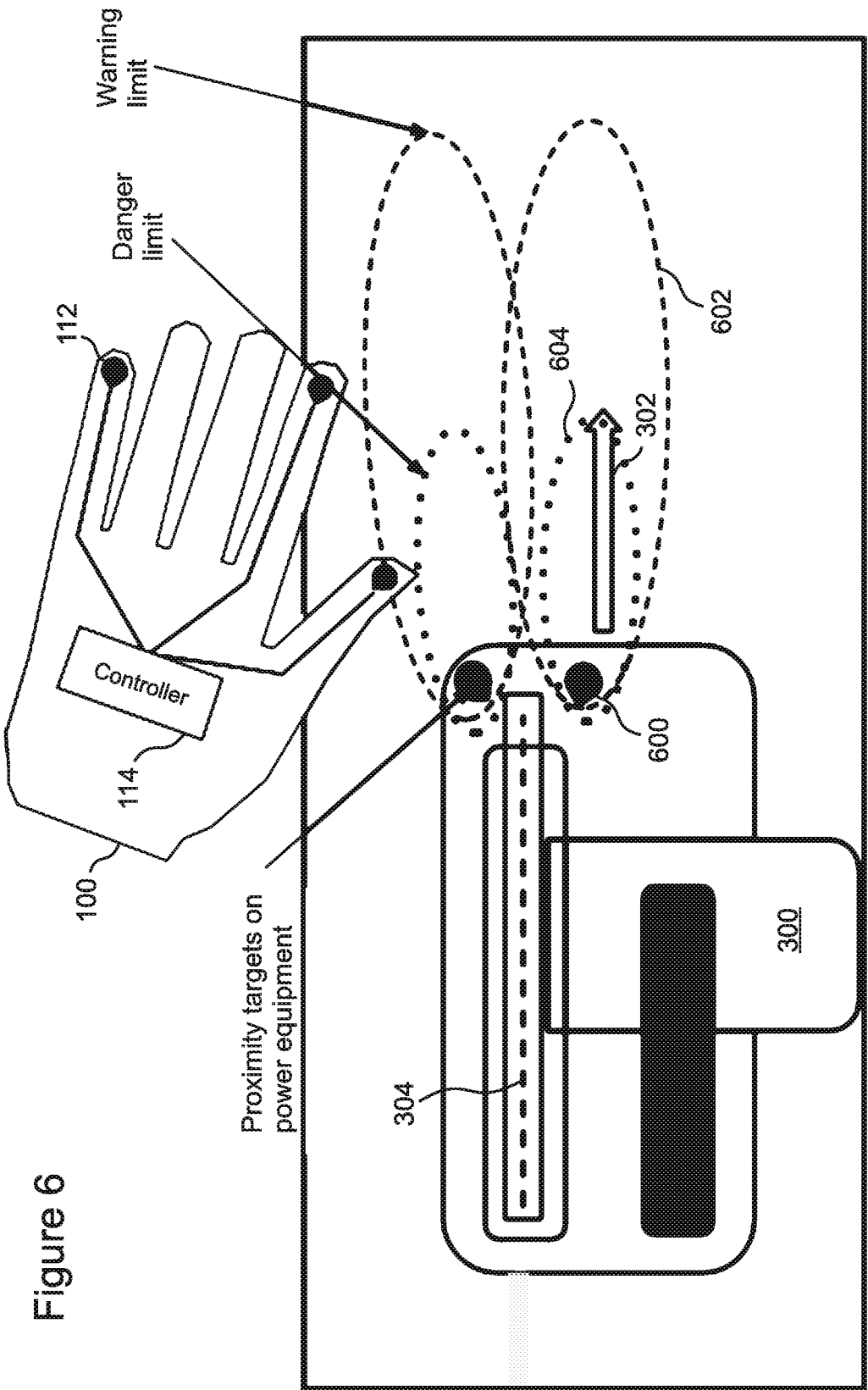


Figure 5B



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/024000**A. CLASSIFICATION OF SUBJECT MATTER****A61B 5/00(2006.01)i**

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)

A61B 5/00; F16P 3/06; A41D 19/015; F16P 3/14; G08B 21/00; A41D 19/00; F16P 3/12; G08B 23/00

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: power, safe, garment, glove, proximity, sensor, detect, control

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 1086334 B1 (INTELLIGENT SAFTY DEVELOPMENT) 25 February 2004 See claims 1-17 and figures 2-5.	1-4, 6-8, 10-26
Y		5, 9, 27
Y	US 2005-0017868 A1 (YANG) 27 January 2005 See paragraphs [32],[42] and figures 2,4.	5, 27
Y	KR 20-2015-0001872 U (DAEWOO SHIPBUILDING & MARINE ENGINEERING CO., LTD.) 18 May 2015 See paragraph [28] and claim 4.	9
A	US 05315289 A (FULLER et al.) 24 May 1994 See claims 1-26 and figure 1.	1-27
A	KR 10-2014-0060917 A (WOO BYUNG RUYNG et al.) 21 May 2014 See claims 1-7 and figure 1.	1-27



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

05 June 2017 (05.06.2017)

Date of mailing of the international search report

07 June 2017 (07.06.2017)

Name and mailing address of the ISA/KR

International Application Division

Korean Intellectual Property Office

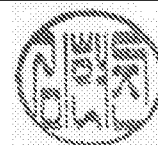
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea

Facsimile No. +82-42-481-8578

Authorized officer

KIM HYEON JIN

Telephone No. +010-4310-7635



INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2017/024000

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 1086334 B1	25/02/2004	AT 260436 T AU 1999-41485 A1 AU 4148599 A CA 2334772 A1 CZ 20004731 A3 EP 1086334 A1 FR 2779669 A1 FR 2786068 A1 JP 2002-518650 A PL 344993 A1 TW 479117 B WO 99-66253 A1	15/03/2004 05/01/2000 05/01/2000 23/12/1999 15/08/2001 28/03/2001 17/12/1999 26/05/2000 25/06/2002 19/11/2001 11/03/2002 23/12/1999
US 2005-0017868 A1	27/01/2005	US 7564361 B2	21/07/2009
KR 20-2015-0001872 U	18/05/2015	None	
US 05315289 A	24/05/1994	EP 0533329 A2 EP 0533329 A3 WO 93-06570 A1	24/03/1993 26/05/1993 01/04/1993
KR 10-2014-0060917 A	21/05/2014	None	

专利名称(译)	便携式安全警告与测量系统的研究		
公开(公告)号	EP3432782A4	公开(公告)日	2019-11-13
申请号	EP2017771229	申请日	2017-03-24
[标]申请(专利权)人(译)	WARWICK MILLS		
申请(专利权)人(译)	WARWICK MILLS , INC.		
当前申请(专利权)人(译)	沃里克米尔斯公司		
[标]发明人	HOWLAND CHARLES A HOWLAND JOHN C		
发明人	HOWLAND, CHARLES A. HOWLAND, JOHN C.		
IPC分类号	A61B5/00		
CPC分类号	A41D19/0027 A61B5/6806 B25F5/00 F16P3/145 F16P3/147 F16P3/148 A41D19/0031 A61B5/01		
优先权	62/312490 2016-03-24 US		
其他公开文献	EP3432782A1		
外部链接	Espacenet		

摘要(译)

一种用于保护动力工具使用者的设备，包括手套或其他衣服，该手套或其他衣服具有至少一个监测对动力工具的接近度的传感器。手套的实施例可以包括手指和/或拇指接近传感器，和/或检测手的位置，手指和/或腕关节角度，振动和/或加速度的传感器。感应目标可以追溯安装在电动工具上，并且可以定义警告和/或危险区域。可以通过磁性，电磁，电容，涡流和/或测距装置进行感测。可以通过从各种检测范围的多个目标中选择目标来控制警告和/或目标区域的大小。保护响应可以根据不同的感测事件而变化，并且可以包括听觉，视觉和/或触觉警报和/或工具电源中断。实施例可以在工作会话期间记录接近度和/或状态数据，以用于审查，培训和认证目的。控制器可以与服装物理协作。