



(51) International Patent Classification:

B25H 1/00 (2006.01) **B62D 63/04** (2006.01)
B60B 19/00 (2006.01) **B64F 5/00** (2006.01)
G05D 1/08 (2006.01) **B23Q 9/00** (2006.01)
B25J 5/00 (2006.01)

(21) International Application Number:

PCT/US2014/038699

(22) International Filing Date:

20 May 2014 (20.05.2014)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

13/931,165 28 June 2013 (28.06.2013) US

(71) Applicant: **THE BOEING COMPANY** [US/US]; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US).

(72) Inventors: **SPISHAK, Noel A.**; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US). **RICHARDS, Charles M.**; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US). **HANSEN, Jeff**; 100 North Riverside

Plaza, Chicago, Illinois 60606-2016 (US). **MOORE, Stephen G.**; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US). **DAY, Dan D.**; 100 North Riverside Plaza, Chicago, Illinois 60606-2016 (US).

(74) Agents: **SLENKER, Robert** et al.; The Boeing Company, PO Box 2515, MC 110-SD54, Seal Beach, California 90740-1515 (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, LT, 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, SZ, TZ,

[Continued on next page]

(54) Title: MAGNET SENSING HOLE DRILLER AND METHOD THEREFOR

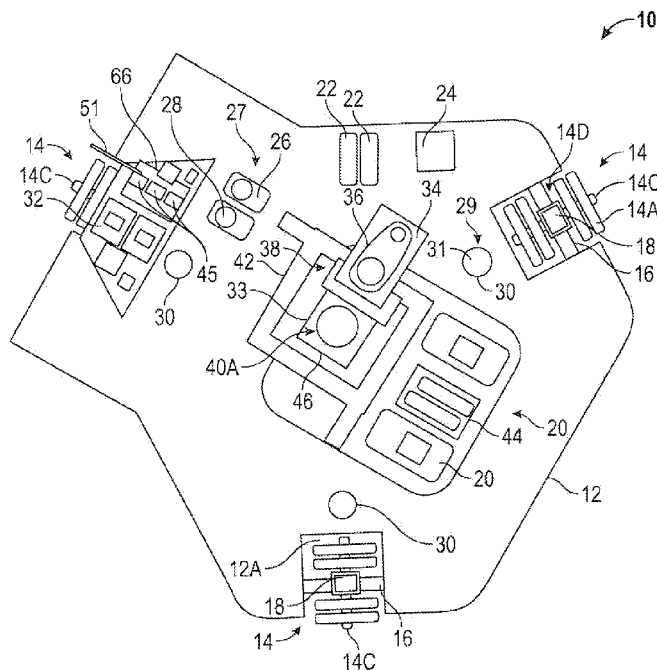


FIG. 1

(57) Abstract: A portable device to drill holes has a platform. A plurality of wheel sets is coupled to the platform. A drive system is used for driving the plurality of wheels. An attachment mechanism is positioned on an underside of the platform for securing the device to a surface. A control board is used for controlling the operation of the device. A drill assembly is coupled to the platform. A drill feed assembly is coupled to the drill assembly for raising and lowering the drill spindle assembly. A drive table is used for positioning the drill assembly in an XY plane. A power supply is used for powering the device. An antenna is coupled to the control board for sending location information and receiving drill locations. Sensors are used for finding drill locations.



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))*

MAGNET SENSING HOLE DRILLER AND METHOD THEREFOR**BACKGROUND**

Embodiments of this disclosure relate generally to a manufacturing device, and more particularly, to a portable, Computer Numerical Control (CNC) machine that moves along assembly surfaces to drill holes.

It may be desirable to locate, with a certain degree of accuracy and specificity, locations in a blind area of a working surface. For example, if it is desired to affix together two portions of a structure, where only an outside surface is visible to a work person, it may be difficult to precisely and reproducibly place a fastener between the two portions. This may be particularly relevant in regards to aircraft where the skin of the aircraft may be placed over an internal frame structure and affixed thereto. In the above case, once the skin is in place, it may be difficult to locate a fastener that may first go through the skin to be affixed to the internal structure of the aircraft. This situation arises in other construction and manufacturing instances as well.

Presently, one solution has been the attempt to back drill from inside the structure. In the above aircraft scenario, it may be a common practice to back drill the wing skin holes from inside the wing using pre-drilled holes in ribs and spars as the templates. However, this may lead to off-angle holes and subsequent required rework.

During back drilling, a work person physically places themselves inside the structure, often in areas where spacing may be tight. The person then drills through the sub-structure and through the skin. This, however, may create impreciseness in the holes. Furthermore, it may be hard on the work person who may have crawl or reach into small areas to create the holes.

Backmarkers may also be used in the aircraft industry to transfer holes from the understructure to the outside surface. Backmarkers may consist of a long split piece of thin metal with a pin on one side and a hole on the other that are in alignment. The pin side may be

slipped under the skin to line up with a pilot hole in the understructure, and a pilot hole is drilled into the outer skin. However, deflection of the split plates and the difficulty of installing the device on thick parts may limit the use to thin areas near the edge of the skin.

Another method may be to use a probe or locating device to determine a precise position on the skin. The probe is generally programmed with locations in three dimensional space. When a surface is placed within reach of the probe, the probe can determine the location of a point which the probe touches. This, however, requires an extensive pre-programming and precise placement of the surface to be probed. Using such special orientation probes increases time and manufacturing costs for many applications.

Therefore, it would be desirable to provide a system and method that overcomes the above.

SUMMARY

According to one aspect of the disclosure, a portable device to drill holes having a platform is provided. A plurality of wheel sets is coupled to the platform. A drive system is used for driving the plurality of wheels. An attachment mechanism is positioned on an underside of the platform for securing the device to a surface. A control board is used for controlling operating of the device. A drill assembly is coupled to the platform. A drill feed assembly is coupled to the drill assembly for raising and lowering the drill spindle assembly. A drive table is used for positioning the drill assembly in an XY plane. A power supply is used for powering the device. An antenna is coupled to the control board for sending location information and receiving drill locations. Sensors are used for finding drill locations.

Advantageously, the device further comprises a normality system for adjusting an angle between the platform and the surface to be drilled. Preferably, the normality system comprises a pivot angle measuring device, a control unit coupled to the pivot angle measuring device, and a

normality motor coupled to the control unit for raising and lowering a portion of the platform. Preferably, the normality system has a plurality of multi-core processors, wherein each core of each processor is programmed to perform a specific function. Advantageously, each wheel set comprises a wheel pivot assembly attached to the platform, and at least one wheel rotatably coupled to the wheel pivot assembly. Preferably, the at least one wheel is an Omni wheel. Advantageously, the drive system comprises individual drive systems for each of the plurality of wheel sets. Advantageously, the attachment mechanism comprises a plurality of suction cups positioned on the underside of the platform, and a vacuum system coupled to the plurality of suction cups. Advantageously, the sensors are magnetoresistive and can measure and divide an output field strength into X, Y & Z components. Advantageously, the drill assembly comprises a drill spindle, a spindle motor; and wherein a drill feed motor is coupled to the drill feed assembly.

According to a further aspect of the disclosure, a portable device for use in product assembly is provided which has a platform. A plurality of wheel sets is coupled to the platform. A drive system is used for driving the plurality of wheel sets. An attachment mechanism is used for securing the device to a surface for an assembly operation. A plurality of sensors is used for finding a location on the surface where the assembly operation is to be performed based on detection of at least one magnet positioned under the surface. A normality system is used for adjusting an angle between the platform and the surface where the assembly operation is to be performed.

Advantageously, the normality system comprises a pivot angle measuring device, a control unit coupled to the pivot angle measuring device, and a normality motor coupled to the control unit for raising and lowering a portion of the platform. Preferably, the normality system has a plurality of multi-core processors, wherein each core of each processor is programmed to perform a specific function. Preferably, the plurality of sensors is magnetoresistive and can

measure and divide an output field strength into X, Y & Z components. Advantageously, the plurality of wheel sets are Omni wheel sets. Advantageously, the drive system comprises individual drive systems for each of the plurality of wheel sets. Advantageously, the attachment mechanism comprises a plurality of suction cups positioned on the underside of the platform, and
5 a vacuum system coupled to the plurality of suction cups.

According to a yet further aspect of the disclosure, a process for operating a portable autonomous device to drill holes is provided which comprises transmitting a signal to the portable autonomous device to move to a drill location on a surface; receiving a location update
10 from the portable autonomous device; determining whether the updated location is the drill location; aligning a drill assembly of the portable autonomous device to the drill location; activating an attachment device of the portable autonomous device to fix a position of the portable autonomous device; activating magnet sensors and an XY drive to locate a magnet; and activating a drill feed assembly of the portable autonomous device to lower the drill assembly.

15 Advantageously, the process further comprises activating a set of sensors to find a precise position of a temporary magnet located in a position of the drill location and adjusting a drive table of the portable autonomous device to center the drill assembly over the temporary magnet based on readings from the set of sensors. Advantageously, the process further comprises adjusting an angle between a platform of the device and the surface to be drilled.

20 The features, functions, and advantages may be achieved independently in various embodiments of the disclosure or may be combined in yet other embodiments.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the disclosure will become more fully understood from the detailed description and the accompanying drawings, wherein:

5 **FIG. 1** illustrates a top schematic view of a magnetic sensing hole driller;

FIG. 2 illustrates a perspective view of the magnetic sensing hole driller;

FIG. 3 is a magnified perspective view of a wheel pivot assembly used in the magnetic sensing hole driller;

10 **FIG. 4** is a magnified perspective view of the drill assembly used in the magnetic sensing hole driller;

FIG. 5 is a bottom view of the sensors used in the magnetic sensing hole driller;

FIG. 6 is a perspective view of the platform and wheel pivot assembly of the magnetic sensing hole driller;

15 **FIG. 7** is a simplified block diagram showing one embodiment of operation of the normality system used in the magnetic sensing hole driller;

FIG. 8 is a simplified block diagram showing one embodiment of operation of the normality system used in the magnetic sensing hole driller;

FIG. 9 is a simplified block diagram showing one embodiment of operation of the normality system used in the magnetic sensing hole driller;

20 **Fig. 10** illustrates a flowchart of a method of using an embodiment of the magnetic sensing hole driller; and

FIG. 11 is a schematic diagram illustrating an overall view of communication devices, computing devices, and mediums for implementing the magnetic sensing hole driller.

DETAILED DESCRIPTION

Referring now to **FIGs. 1** and **2**, an embodiment of a magnet sensing hole drilling device **10** (hereinafter device **10**) is shown. The device **10** may be configured as a portable, mobile, autonomous computer numerical control (CNC) machine that may move along assembly surfaces to drill initial holes, the locations of which may be determined via a coordinate measurement system, and whose positions may be refined using a magneto-resistive sensor that senses a temporary magnet in the part. While the device **10** is described below as being used as a drill, the device **10** may be useful in a wide range of areas besides drilling, such as inspection, photographing, applying sealant or adhesive, painting, cleaning or anything requiring a compact autonomous device on a large structure.

The device **10** may have a platform **12**. The platform **12** may be used to support a plurality of components of the device **10**. While the platform **12** shown in **FIGs. 1** and **2** is triangular in shape, the platform **12** may be formed in other shapes without departing from the spirit and scope.

Attached to the platform **12** is a plurality of wheel sets **14** for moving the device **10**. While the present embodiment shows three wheel sets **14**, this is shown as one example and should not be seen in a limiting manner. The wheel set **14** may be formed of one or more wheels **14A**, an axle **14C** between the wheels, a gearbox **14D**, and an independent drive system **18**. The wheel set **14** may be attached to a wheel pivot assembly **16**. The wheel pivot assembly **16** attaches to platform **12** and allows the wheel set **14** to rotate about the wheel pivot assembly **16** so that all wheels **14A** will maintain contact with the surface. In the embodiment shown in **FIGs. 1** and **2**, each wheel set **14** has two pairs of wheels **14A** for a total of four wheels **14A** per wheel set **14**.

Any type of wheel **14A** may be used in the wheel set **14**. In accordance with one embodiment, the wheel sets **14** may be comprised of one or more Omni wheels. Omni wheels

are a type of wheel which may have small discs **14B** formed around a circumference of the wheel **14A**. The discs **14B** may be formed perpendicular to the rolling direction. The effect is that each wheel **14A** with the discs **14B** may roll with full force, but can also slide laterally with great ease.

5 As may be seen in **FIG. 3**, the wheel sets **14** may be designed so both pairs of wheels **14A** in each wheel set **14** remain in contact with the surface. This may be accomplished by allowing the wheel sets **14** to pivot about an axis Pivot CL. This pivoting ensures that all four wheels **14A** are on the surface and this enables the device **10** to maintain normality and traction.

Referring back to **FIGs. 1** and **2**, in the embodiment shown in **FIGs. 1** and **2**, the wheel
10 sets **14** may be attached at the vertices of the platform **12**. However, this is shown as an example and should not be seen in a limiting manner. The wheel sets **14** may be attached to the platform **12** in different manners. As shown in the present embodiment, cut-outs **12A** may be formed in the platform **12**. The wheel pivot assembly **16** may be coupled across the cut-out **12A** such that the wheel sets **14** may be positioned within the cut-out **12A**.

15 The wheel sets **14** may be driven by a drive system **18**. In accordance with one embodiment, each wheel set **14** may be driven by an independent drive system **18**. The drive system **18** may be comprised of an independent motor and gear system or the like. The above description of the drive system **18** is shown as an example and should not be seen in a limiting manner.

20 The device **10** may have a power source **20**. The power source **20** may be used to power the different components of the device **10**. In accordance with one embodiment, the power source **20** may be batteries **20A**. Additional embodiments may have an electrical cable to supply the device **10** with power, or solar cells may be used as a charging/power source. The power source **20** may be coupled to one or more DC converters **22**. The DC converters **22** may be used
25 to adjust the voltage applied to the different components of the device **10**. A switch **24** may also

be coupled to the power source **20**. The switch **24** may be used to control the energization of the device **10**.

The device **10** may have an attachment mechanism **29** to secure the device **10** to a manufacturing surface and hold the device **10** steady during the drilling process. In accordance with one embodiment, the attachment mechanism **29** may be comprised of suction cups **31** positioned on the underside of the platform **12**. The suction cups **31** may be coupled to vacuum system **27** that controls air flow to the suction cups **31**. The vacuum system **27** may be comprised of an air pump **26** and vacuum pump **28** which controls airflow to air cylinders **30** that are in fluid communication with the suction cups **31**.

The device **10** may have a drill assembly **33** for drilling holes. In accordance with one embodiment, the drill assembly **33** may have a drill spindle assembly **40** consisting of a spindle motor **40A** and a drill spindle **40B** for holding a drill bit **50**. A spindle motor **40A** may be used to power and rotate the drill spindle **40B**. The above is given as one example of the drill assembly **33** and should not be seen in a limiting manner. A spindle control **44** may be coupled to the drill assembly **33** to control the drill speed.

The drill assembly **33** may be coupled to a drill feed assembly **38**. The drill feed assembly **38** may be used to raise and lower the drill spindle assembly **40**. The drill feed assembly **38** may be coupled to a drill feed motor **34**. The drill feed motor **34** may be used to raise and lower the drill spindle assembly **40**. A drill feed belt **36** may be coupled to the drill feed motor **34** and the drill feed assembly **38**. The drill feed belt **36** may be used to transfer power from the drill feed motor **34** to the drill feed assembly **38** to raise and lower the drill spindle assembly **40**.

The drill assembly **33** and drill feed assembly **38** may be mounted on a drive table **42**. The drive table **42** may be used to move the drill assembly **33** in an XY plane. Thus, the drive table **42** may be used for fine positioning of the drill assembly **33** and the drill bit **50** over a

desired area.

The device **10** may have sensors **46**. The sensors **46** may be mounted under the XY drive table **42** and move with the XY drive table **42**. The sensors **46** may be used for detecting drill location. In accordance with one embodiment, the sensors **46** may be magnetic sensors which
5 may be used for detecting drill location magnets that may be prepositioned under a work surface to which the device **10** is attached and operating.

Referring now to Figures 1-5, in accordance with one embodiment, the sensors **46** may be magnetoresistive. Thus, the sensors **46** may divide the output field strength into X, Y & Z components. One or more microprocessors **45** on a control board **32** described below may be
10 used to process the field strength readings and command the XY drive table **42** to move until it determines the magnet that is located under the wing surface is centered beneath the sensors **46**. Knowing the X, Y & Z components of magnetic strength and direction enable the microprocessor **45** to not only find the center of the magnet, but also determine the magnet depth and polar alignment. From that information a quality check can be made to ensure proper
15 magnet installation prior to drilling.

The device **10** may have a control board **32**. The control board **32** may have one or more microprocessors **45** and memory for storing software or firmware for operating the device **10**, as well as for error detection and tracking assembly performance and quality metrics. The control board **32** may also control a fastener insertion system, and a drill normality system **52** that
20 detects and aligns the drill assembly **33**. An antenna **51** may be in communication with the control board **32** to send and receive wireless control signals to and from the control board **32**.

Referring now to **Figures 1-9**, the normality system **52** will be described in more detail. The normality system **52** may be used to raise and lower the platform **12** to achieve a proper drill angle to the surface. As may be seen in **FIG. 6**, the drill assembly **33** may need to be positioned
25 outside of a line drawn between two front wheel sets **14**. The position of the drill assembly **33**

may allow drilling along an edge of a curved surface such as a wing panel or the like. However, moving the drill assembly **33** outside of the line drawn between two front wheel sets **14** may require a system to sense and adjust the device's normality to the curved surface. On a curved surface the wheel sets **14** may pivot. Thus, the angle of the pivot may need to be determined in order to achieve a proper drill angle.

To measure the pivot of the wheel sets **14**, a pivot angle measuring device **60** may be coupled to the platform **12**. In accordance with one embodiment, the pivot angle measuring device **60** may be formed of sensors **62** mounted on the two front wheel sets **14** and encoders **64** mounted on the platform **12**. The encoders **64** may take data measured by the sensors **62** to calculate the pivot angle. With the geometry of the wheel set **14** and the angle of the pivot one can determine the angle the platform **12** may need to be raised or lowered to achieve the proper drill angle to the surface.

A control unit **66** of the normality system **52** takes readings from the pivot angle measuring device **60** and calculates the angle the platform **12** may need to be raised or lowered to achieve the proper drill angle to the surface. Once the calculations are determined, the control unit **66** may send signals to a normality motor **68**. The normality motor **68** may pull or push on a swing arm **70** which may be attached to the wheel set **14** coupled to a rear section of the platform **12**. The swing arm **70** may raise or lower the platform **12** to achieve a proper drill angle to the surface. The control unit **66** may be programmed to have a predefined tolerance. Thus, unless the angle the platform **12** needs to be raised or lowered more than a predefined amount, for example more than 1 degree, the normality system **52** may be programmed not to move the swing arm **70**.

The control unit **66** may have one or more microprocessors **45**. While the Figures may show 5 microprocessors **45**, this is only shown as an example and should not be seen in a limiting manner. In a standard control unit, the control unit uses what may be called a laundry

list and interrupts approach. The control unit works down a list completing each task in order unless an interrupt is received. When an interrupt is received the current instruction is completed before responding to the interrupt. These control units are known as interrupt driven and the total number of interrupt inputs is limited by the processor design.

5 In accordance with one embodiment, the control unit **66** may use a plurality of multi-core microprocessors **45**. The functions of the control unit **66** may be broken into discrete simple tasks. These tasks are exclusively assigned to one of the available cores of the plurality of microprocessors **45**. This makes all functions of the device **10** available all the time if required. Thus, the control unit **66** does not need to go through a laundry list of tasks. The cores of the
10 plurality of microprocessors **45** may share a common registry where their status is available to all cores. Thus, there is no need for interrupts. Updates to the common registry can be made and acted on in as little as 8 nanoseconds, providing more effective control. Implementation of the control unit **66** greatly reduces the complexity and quantity of hardware required to control operation of the device **10**, and adds orders of magnitude improvement in efficiency.

15 Referring to **FIG. 7-9**, operation of the normality system **52** is shown. In **FIG. 7**, the normality system **52** determines that the device **10** is on a surface **72** that is level. Thus, the normality system **52** does not have to raise or lower the platform **12** to achieve a proper drill angle to the surface **72**.

In **FIG. 8**, the normality system **52** determines that the device **10** is on a surface **72** that is
20 slightly curved. The normality system **52** calculates the angle between the platform **12** and the wheel set **14**. In this embodiment, the normality system **52** calculates that the angle is still within a predefined tolerance (for example, the platform **12** is still within 1 degree of being perpendicular to the surface **72**). Thus, the normality system **52** does not have to raise or lower the platform **12** to achieve a proper drill angle to the surface **72**.

25 In **FIG. 9**, the normality system **52** determines that the device **10** is on a surface **72** that is

also slightly curved. The normality system **52** calculates whether the angle between the platform **12** and the wheel set **14** exceeds the predefined tolerances. Thus, the normality system **52** sends signals to raise or lower the platform **12** to achieve a proper drill angle to the surface **72**.

Referring to **FIGs. 1-11** a method of using the device **10** will be described. **FIG. 10** illustrates a flowchart of a method **100** of using an embodiment of the autonomous magnetic hole driller according to an embodiment of the invention. The method **100** may start at step **102** by placing the device **10** on a surface to be drilled or treated and activating the device **10** (step **104**). At step **106**, upon activating the device **10**, the device **10** may transmits a wireless signal via the antenna **51** that may be used to find and determine the location of the device **10**. At step **108**, a cell controller (not shown) may transmit the current location of the device **10** and a target location to be drilled to the device **10**. At step **110**, the device **10** may move to the target drill location. At step **112**, the cell controller may check the position of the device **10** and determines if the position of the device **10** is correct.

If the position is not correct, the cell controller may retransmit the current location of the device **10** and the desired drill location. If the position of the device **10** is correct, the suction cups **31** may be activated by applying vacuum pressure to fix the position of the AMSHD (steps **116** and **118**). At step **120**, the magnetic sensors may be turned on to find the precise position of the temporary magnet that is located in the position of the hole to be drilled. At step **122**, the device **10** senses the temporary magnet, and the control board **32** may send commands to the drive table **42** to center the drill assembly **33** over the magnet (step **124**). At step **126**, the position of the device **10** may be confirmed again. The angle between the platform **12** and the surface **72** to be drilled may be calculated at step **128** by using the normality system **52**. If the angle calculated exceeds a predetermined threshold value, the normality system **52** may be used to adjust the angle between the platform **12** and the surface **72** as shown in step **130**. Once the correct position of the device **10** has been verified, the drill assembly **33** may be activated (step

132). At step 134, the drill bit 50 may be lowered into contact with the manufacturing surface, the hole may then be drilled, and the drill bit 50 can be retracted. At step 136, a fastener may then be inserted (step 134). At step 138, the device 10 may then await further location positioning commands.

5 FIG. 11 is a schematic diagram illustrating an overall view of communication devices, computing devices, and mediums for implementing an autonomous magnetic hole driller according to embodiments of the invention. The system 200 may include multimedia devices 202 and desktop computer devices 204 configured with display capabilities 214. The multimedia devices 202 may be mobile communication and entertainment devices, such as cellular phones
10 and mobile computing devices that may be wirelessly connected to a network 208. The multimedia devices 202 may have video displays 218 and audio outputs 216. The multimedia devices 202 and desktop computer devices 204 can be optionally configured with internal storage, computing processors, software, and a graphical user interface (GUI) for carrying out elements of the device 10 according to embodiments of the invention. The network 208 is
15 optionally any type of known network including a fixed wire line network, cable and fiber optics, over the air broadcasts, satellite 220, local area network (LAN), wide area network (WAN), global network (e.g., Internet), intranet, etc. with data/Internet capabilities as represented by server 206. Server 206 may be configured as a cell controller (Vicon) for controlling and positioning the device 10. Communication aspects of the network may be represented by
20 cellular base station 210 and antenna 212. In accordance with one embodiment, the network 208 is a LAN and each remote device 202 and desktop device 204 may execute a user interface application (e.g., Web browser) to contact the server system/cell controller 206 through the network 208. Alternatively, the remote devices 202 and 204 may be implemented using a device programmed primarily for accessing network 208 such as a remote client.

25 The software for the operation of device 10, of embodiments of the invention, may be

resident on the individual multimedia devices **202** and desktop computers **204**, device **10** or stored within the server/cell controller **206** or cellular base station **210**.

While embodiments of the disclosure have been described in terms of various specific embodiments, those skilled in the art will recognize that the embodiments of the disclosure may

5 be practiced with modifications within the spirit and scope of the claims.

What is claimed is:

1. A portable device (10) for use in product assembly comprising:
 - a platform (12);
 - a plurality of wheel sets (14) coupled to the platform (12);
 - 5 a drive system (18) for driving the plurality of wheel sets (14);
 - an attachment mechanism (29) for securing the device (10) to a surface (72) for an assembly operation;
 - a plurality of sensors (46) for finding a location on the surface (72) where the assembly operation is to be performed based on detection of at least one magnet positioned under the
 - 10 surface (72); and
 - a normality system (52) for adjusting an angle between the platform (12) and the surface (72) where the assembly operation is to be performed.
2. The device (10) of claim 1, further comprising:
 - a drill assembly (33) coupled to the platform (12);
 - 15 a drill feed assembly (38) coupled to the drill assembly (33) for raising and lowering a drill spindle assembly (40); and
 - a drive table (42) for positioning the drill assembly (33) in an XY plane.
3. The device (10) of claim 1, wherein the normality system (52) comprises:
 - a pivot angle measuring device (60);
 - 20 a control unit (66) coupled to the pivot angle measuring device (60); and
 - a normality motor (68) coupled to the control unit (66) for raising and lowering a portion of the platform (12).
4. The device (10) of claim 1, wherein the normality system (52) has a plurality of multi-core processors (45), wherein each core of each processor (45) is programmed to perform a
- 25 specific function.

5. The device (10) of claim 1, wherein each wheel set (14) comprises:

a wheel pivot assembly (16) attached to the platform (12); and

at least one wheel (14A) rotatably coupled to the wheel pivot assembly (16).

5 6. The device (10) of claim 5, wherein the at least one wheel (14A) is an Omni wheel.

7. The device (10) of claim 1, wherein the drive system (18) comprises individual drive systems (18) for each of the plurality of wheel sets (14).

8. The device (10) of claim 1, wherein the attachment mechanism (28) comprises:

a plurality of suction cups (31) positioned on the underside of the platform (12); and

10 a vacuum system (22) coupled to the plurality of suction cups (31).

9. The device (10) of claim 1, wherein the sensors (46) are magnetoresistive and can measure and divide an output field strength into X, Y & Z components.

10. The device (10) of claim 1 further comprising a control board (32) operable to transmit a signal that is used to find and determine a location of said device (10) and receive
15 signals that provide said device (10) a target location for drilling.

11. A process for operating a portable autonomous device to drill holes comprising:

transmitting a signal to the portable autonomous device to move to a drill location on a surface;

receiving a location update from the portable autonomous device;

20 determining whether the updated location is the drill location;

aligning a drill assembly of the portable autonomous device to the drill location;

activating an attachment device of the portable autonomous device to fix a position of the portable autonomous device;

activating magnet sensors and an XY drive to locate a magnet; and

25 activating a drill feed assembly of the portable autonomous device to lower the drill

assembly.

12. The process of claim 11, further comprising:

activating a set of sensors to find a precise position of a temporary magnet located in a position of the drill location; and

5 adjusting a drive table of the portable autonomous device to center the drill assembly over the temporary magnet based on readings from the set of sensors.

13. The process of claim 11, further comprising adjusting an angle between a platform of the device and the surface to be drilled.

1/8

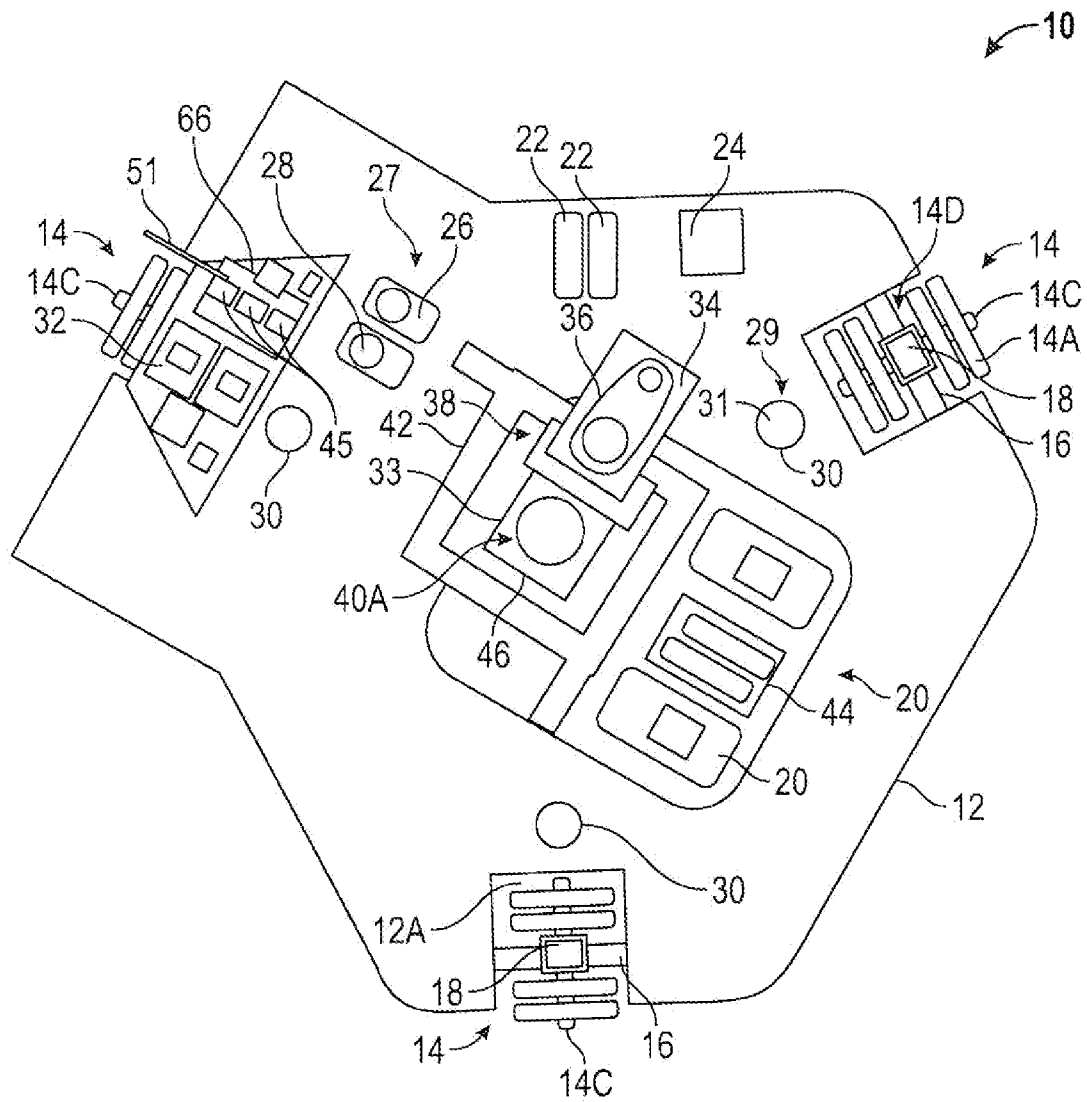


FIG. 1

2/8

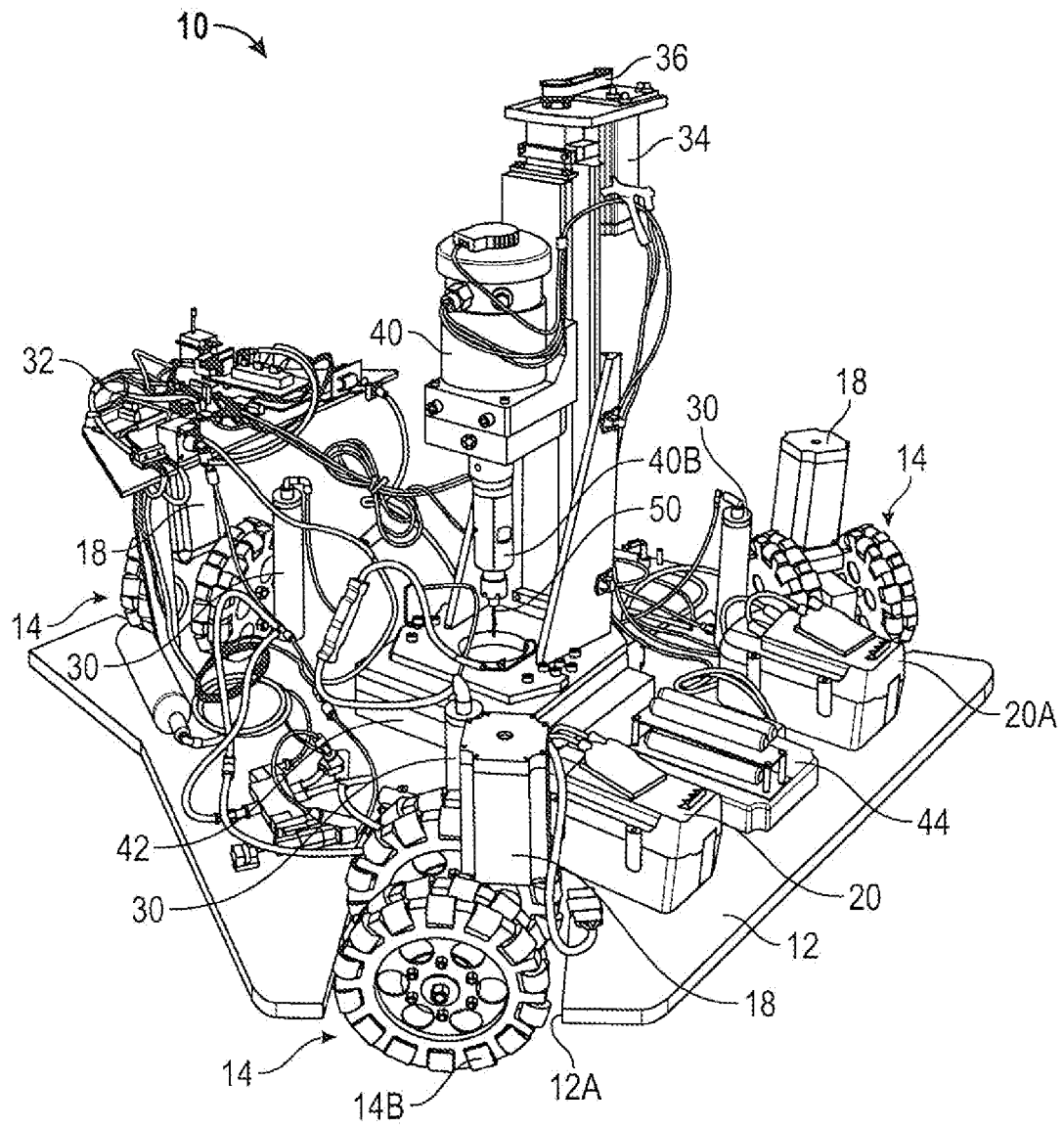


FIG. 2

3/8

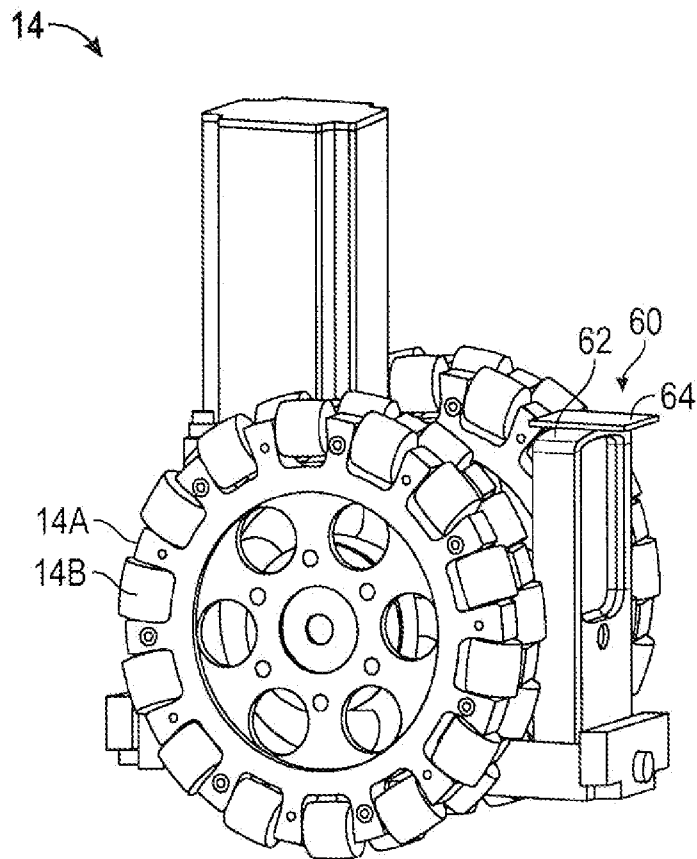


FIG. 3

4/8

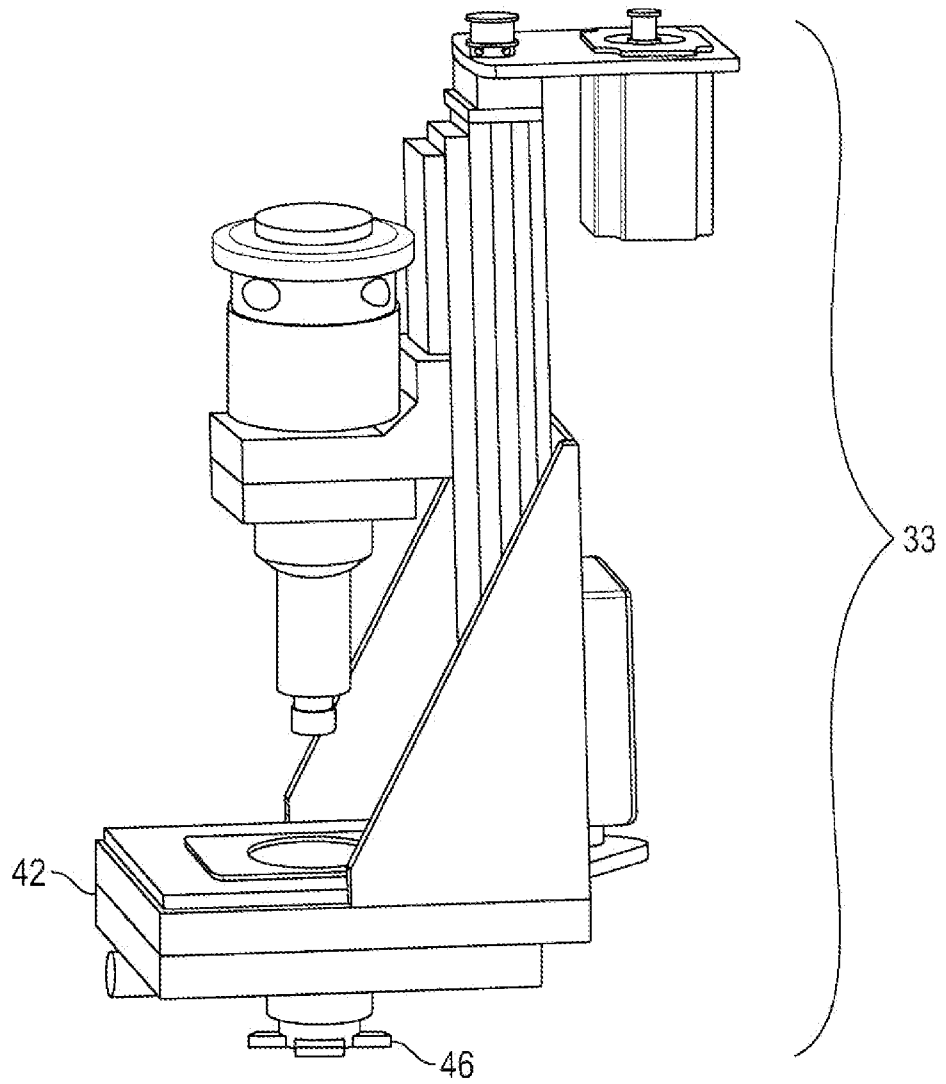


FIG. 4

5/8

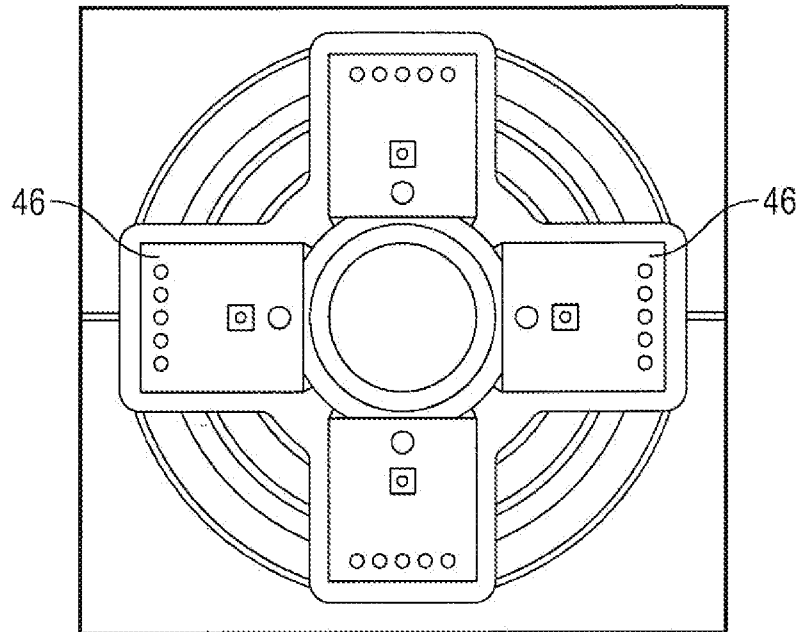


FIG. 5

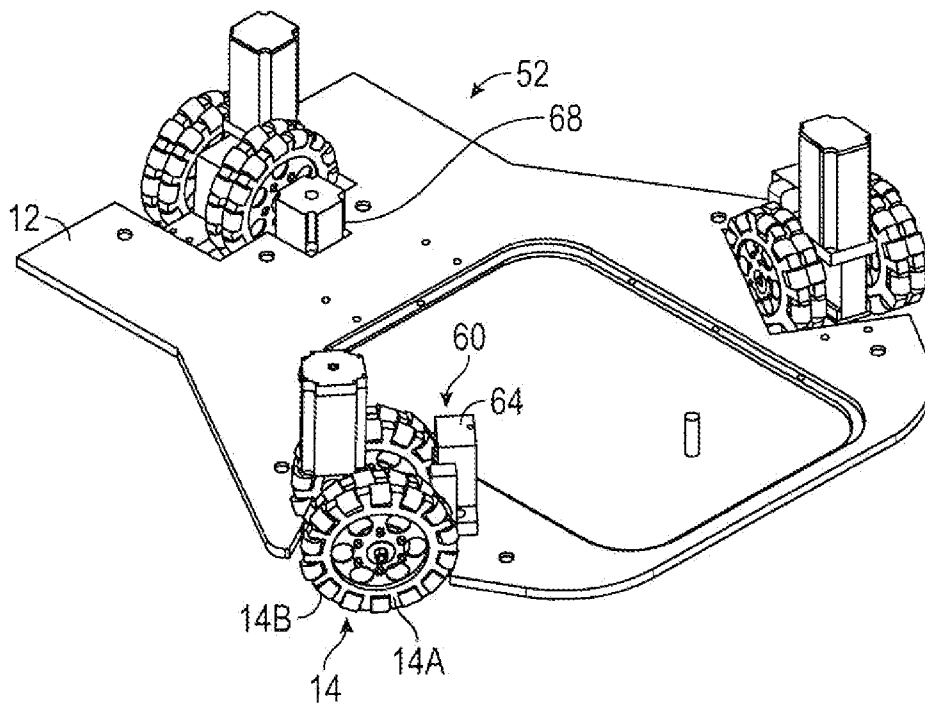


FIG. 6

6/8

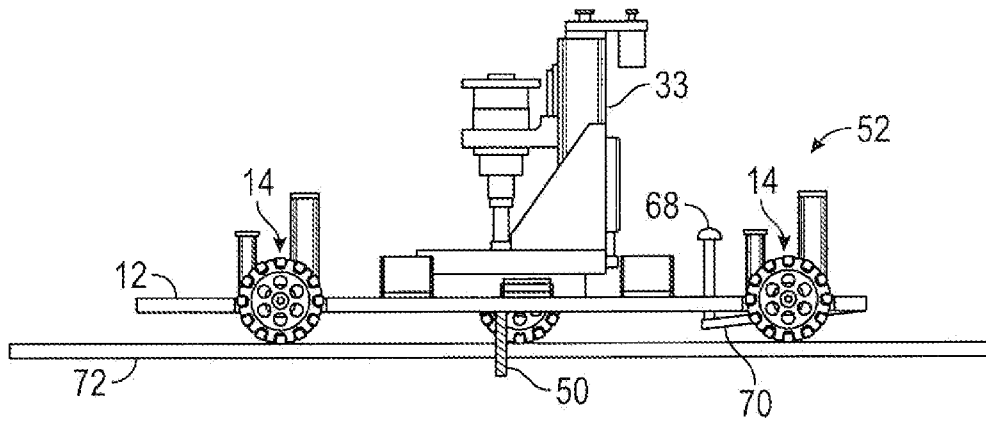


FIG. 7

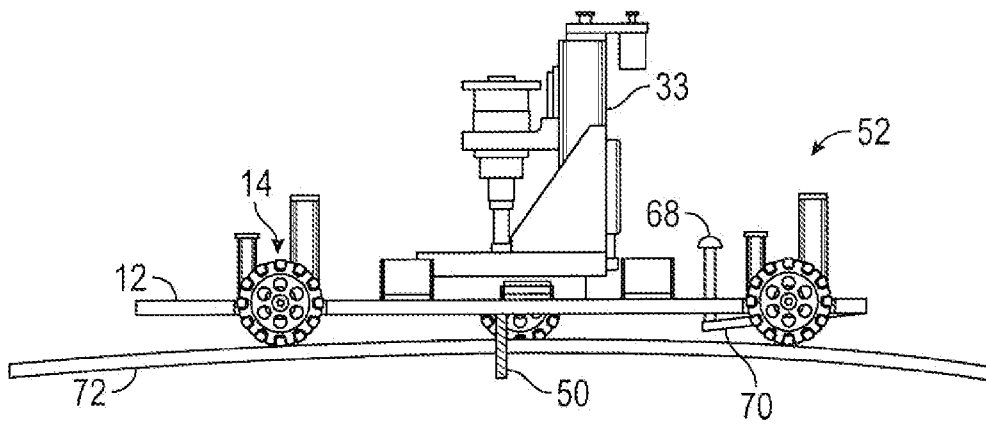


FIG. 8

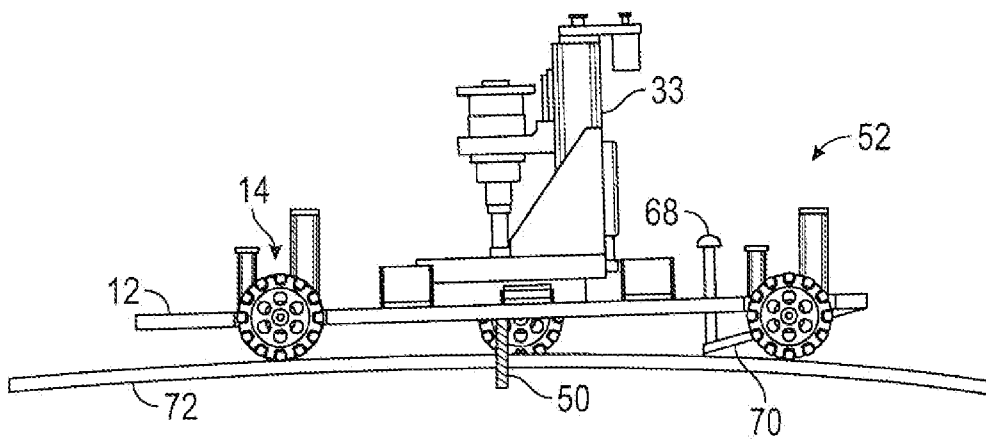


FIG. 9

7/8

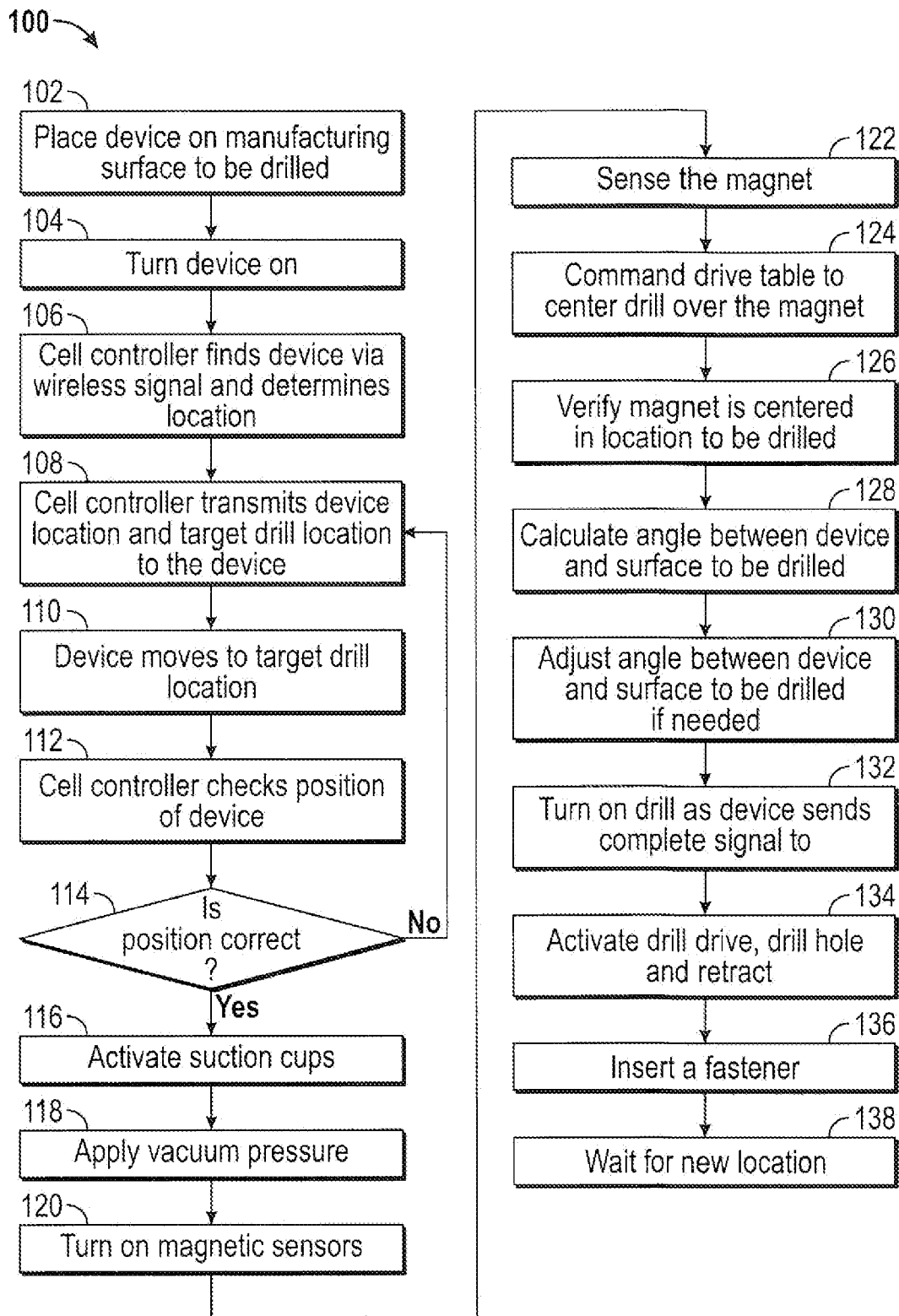


FIG. 10

8/8

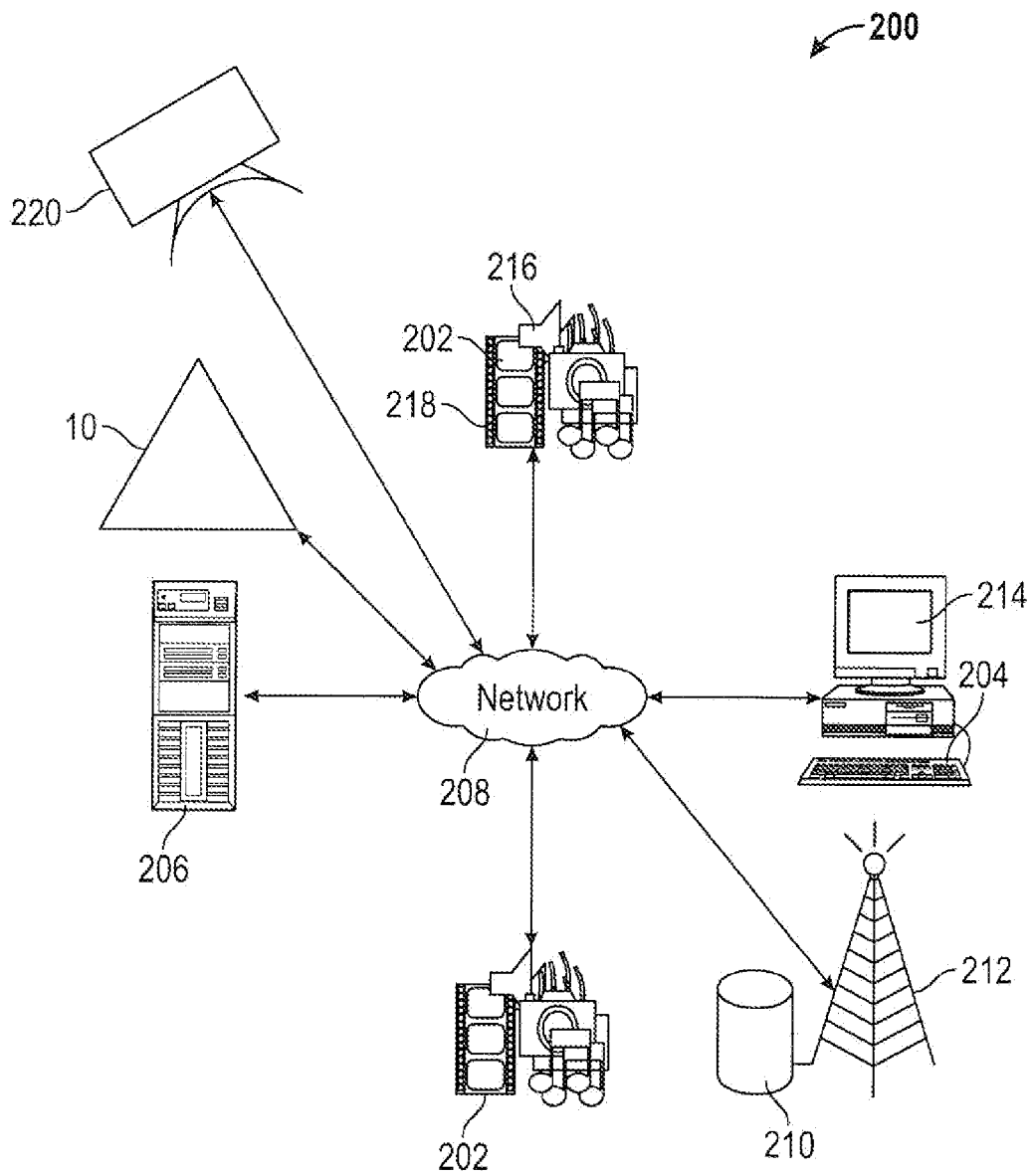


FIG. 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/038699

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	B25H1/00 B64F5/00	B60B19/00 B23Q9/00
	G05D1/08	B25J5/00 B62D63/04
ADD.		
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) B25H B24C B60B G05D B25J B62D B64F B23Q		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	EP 1 792 673 A2 (DUERR SPECIAL MATERIAL HANDLIN [DE]) 6 June 2007 (2007-06-06) paragraphs [0097], [0099], [0103], [0110], [0119], [0121], [0126], [0132]; figures 1-4	1-13
Y	US 2005/052898 A1 (ARNTSON PAUL R [US]) 10 March 2005 (2005-03-10) paragraphs [0001], [0042] - [0045]; figures 3-5	1-3, 10-13
Y	EP 1 132 164 A2 (BOEING CO [US]) 12 September 2001 (2001-09-12) paragraph [0017]; figures 1-3,5,6,7,16	1-3, 11-13
Y	EP 2 239 088 A1 (BOEING CO [US]) 13 October 2010 (2010-10-13) paragraph [0054]; figures 4,5	4
A	-/--	1-3
☒ 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 15 August 2014		Date of mailing of the international search report 21/08/2014
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Matzdorf, Udo

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2014/038699

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	DE 10 2007 016662 A1 (KUKA ROBOTER GMBH [DE]) 9 October 2008 (2008-10-09)	5-7
A	paragraphs [0016], [0019], [0071] - [0073]; figure 11 -----	1,3
Y	JP 2008 179187 A (YASKAWA ELECTRIC CORP) 7 August 2008 (2008-08-07) abstract; figures -----	5-7
Y	DE 10 2011 052602 A1 (SET SCIENT & EFFICIENT TECHNOLOGIES LTD [DE]) 29 November 2012 (2012-11-29)	8
A	paragraphs [0028] - [0030]; figure 2 -----	1,11-13
Y	GB 2 363 462 A (SHEPHARD NICHOLAS ROBERT [GB]; LOMAX TIMOTHY DAVID [GB]) 19 December 2001 (2001-12-19) claims 1,2,7; figures 2,3 -----	9
A	FR 2 809 034 A1 (S O C O A SOC DE CONCEPTION CO [FR]) 23 November 2001 (2001-11-23) page 9, lines 16-32; figures -----	8,11-13

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2014/038699

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
EP 1792673	A2	06-06-2007	DE 102005058493 A1	06-06-2007
			EP 1792673 A2	06-06-2007

US 2005052898	A1	10-03-2005	EP 1664847 A1	07-06-2006
			JP 2007504461 A	01-03-2007
			US 2005052898 A1	10-03-2005
			US 2007114989 A1	24-05-2007
			WO 2005024466 A1	17-03-2005

EP 1132164	A2	12-09-2001	DE 60113745 T2	22-06-2006
			EP 1132164 A2	12-09-2001
			US 6357101 B1	19-03-2002
			US 2002050043 A1	02-05-2002

EP 2239088	A1	13-10-2010	CA 2699031 A1	06-10-2010
			CN 101856731 A	13-10-2010
			EP 2239088 A1	13-10-2010
			ES 2394612 T3	04-02-2013
			JP 2010241423 A	28-10-2010
			RU 2010113198 A	20-10-2011
			US 2010254778 A1	07-10-2010

DE 102007016662	A1	09-10-2008	DE 102007016662 A1	09-10-2008
			EP 2142384 A1	13-01-2010
			US 2010224427 A1	09-09-2010
			WO 2008122538 A1	16-10-2008

JP 2008179187	A	07-08-2008	NONE	

DE 102011052602	A1	29-11-2012	NONE	

GB 2363462	A	19-12-2001	NONE	

FR 2809034	A1	23-11-2001	NONE	
