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## (54) FASTENER DRIVING SYSTEM AND CARRIER FOR A FASTENER DRIVER

(57) A carrier (100, 200) for use with a fastener driver (290) and a method (300) for discharging fastening elements at uniformly spaced intervals from a fastener driving system (205) comprising the fastener driver (290) and the carrier (100, 200) is disclosed. The carrier (100, 200) includes: a platform (110, 210) for supporting the fastener driver (290); at least one motion element (120a, 120b, 120c, 120d, 220a, 220b, 220c, 220d) coupled to said platform (110, 210) and supporting the carrier (100, 200) for motion over a surface (180, 280) to be fastened; an imaging sensor (130, 230) attached to said platform (110, 210) and configured to determine and output values of displacement traversed by said carrier (100, 200) as it moves over the surface (180, 280); and a processor (140, 240) operably coupled to said imaging sensor (130, 230), and configured to receive the said displacement values and calculate based thereon a distance traversed by the carrier (100, 200), wherein the processor (140, 240) is further configured to compare the calculated distance with a predetermined spacing value and generate a signal in response to the calculated distance having a magnitude equal to or greater than the predetermined fastener spacing value. The predetermined spacing value corresponds to the spacing with which fastening elements are to be discharged from the fastening driver (290) and thus the pitch of the fastening elements in the fastened surface.

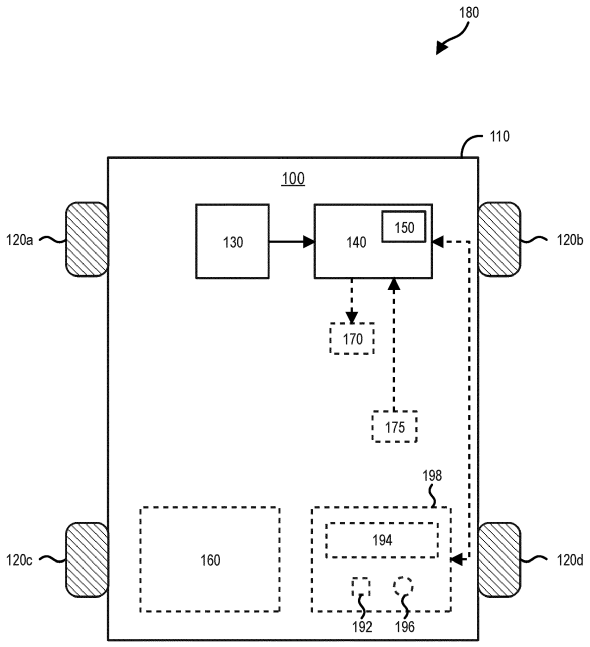


FIG. 1

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## Description

### TECHNICAL FIELD

**[0001]** The field of the present invention relates generally to systems and methods for driving fasteners, and more particularly, to at least one carrier for use with a fastener driver and at least one fastener driving system comprising the carrier. At least one method for discharging fasteners using the fastener driving system is also disclosed.

### BACKGROUND OF THE INVENTION

**[0002]** Fasteners find widespread application in the building and construction industry and are used to secure two or more workpieces together. The workpieces to be fastened together may be made from wood, metal or another material. Examples of fasteners include nails, screws, staples and rivets.

**[0003]** Fastener drivers are well known in the art. They are also known as "fastening" tools and are used to drive fasteners such as nails, screws, staples, rivets and the like into the material to be fastened. A nail gun is a good example of a fastener driver. Rivet guns, staplers and screwdrivers are further types of well-known fastener drivers.

**[0004]** Fastener drivers may be operated by pneumatic, electrical, magnetic or even hydraulic means. They are often of the handheld and portable type so they can be transported to the specific location of the material where fasteners need to be deployed.

**[0005]** Operation of such drivers normally requires that the operator carry the full weight of the relatively heavy tool and bend over or extend oneself with the driver in order to engage the surface to be fastened. Furthermore, the deployed fasteners sometimes need to be spaced at a predetermined and/or uniform distance relative to one another.

**[0006]** For these reasons conventional fastener drivers are sometimes mounted onto a carriage, chassis or similar structure which can be easily moved over a surface of the one or more materials to be fastened. Often the carriage also provides a means for controlling actuation of the fastener driver in response to movement of the carriage along the surface to provide the predetermined fastener spacing.

**[0007]** U.S. Pat. No. 6,736,303 describes a fastening system for driving fasteners through fastener caps. The fastening system includes a nail gun, an actuator system and a fastener cap dispenser, all mounted on a rolling chassis. The actuator system includes a wheel and an actuator in communication with the nail gun. As the actuating wheel rotates, structures on the wheel such as bumps intermittently engage the actuator for signalling the discharge of nails from the nail gun. In this way, the nail gun is able to discharge nails at regular intervals. The patent also discloses that the bumps may be substituted by recesses, teeth, prongs and/or detectable photo-diodes or codes, e.g. bar codes, or electronic codes or chips embedded in the wheel. However, the described invention therein suffers from the shortcoming that, if a different spacing between the fasteners is required, then the radius of the actuating wheel or the number of bumps, recesses, teeth, prongs or other irregularities in the actuating wheel needs to be physically modified. This is undesirable.

**[0008]** U.S. Pat. No. 6,378,197 discloses an automated fastening apparatus that includes a moveable fastening device. The fastening device is provided on a carriage that is moveably mounted to a linearly disposed track. A drive mechanism moves the carriage and fastening device along at least a portion of the track. The track has a plurality of reference holes formed in a top surface of the track that are spaced a predefined distance apart. A photo-electric sensor is also mounted on carriage. As the carriage passes by, the photo-electric sensor detects the reference holes and triggers the fastening device to fire fasteners. In a preferred embodiment, the holes are spaced three inches apart and the gun is programmed to fire on every hole, every other hole, every third hole or every fourth hole, etc., thereby providing fasteners every three, six, nine or twelve inches, respectively. Accordingly, the invention has the disadvantage that if a fastener spacing other than a multiple of three inches is required, the track needs to be replaced with a new track having reference holes at the desired spacing or at least a sub-multiple thereof.

**[0009]** Therefore, there is a need for a carriage or similar structure and a fastener driving system which overcomes the drawbacks of the prior art devices described above. In particular, there is a need for a carriage or similar structure as well as a fastener driving system which conveniently allows the spacing at which fasteners are discharged from the fastener driver to be easily modified.

### SUMMARY OF THE INVENTION

**[0010]** It is an object of the present invention to provide a carrier for a fastener driver which has fewer moving parts and thus is lighter in weight than existing solutions. According to a first aspect, there is provided a carrier for use with a fastener driver, the carrier including a platform for supporting the fastener driver, at least one motion element coupled to said platform and supporting the carrier for motion over a surface to be fastened, an imaging sensor attached to said platform and configured to determine and output values of displacement traversed by said carrier as it moves over the surface and a processor operably coupled to said imaging sensor and configured to receive said displacement values and calculate based thereon a distance traversed by the carrier. The processor is further configured to compare the calculated distance with a predetermined fastener spacing value and generate a signal in response to the calculated distance having a magnitude equal to or greater than the prede-

termined fastener spacing value. The predetermined spacing value corresponds to the spacing with which fastening elements are to be discharged from the fastening driver and thus the pitch of the fastening elements in the fastened surface.

**[0011]** The present invention achieves this aim by employing an imaging sensor and a processor in place of a heavy and sometimes bulky actuating wheel and track with predefined holes. Detaching the measurement of the distance travelled by the carrier from a rotational measurement via the use of an imaging sensor to measure the distance covered by the carrier, results in a lightweight and more robust design since fewer mechanical parts are used.

**[0012]** In a further aspect, said imaging sensor is an optical tracking sensor and comprises a laser.

**[0013]** In yet a further aspect, the carrier further comprises a memory unit coupled to the processor wherein the predetermined fastener spacing value is stored in the memory unit.

**[0014]** In some aspects, the imaging sensor is configured to detect a motion of the carrier relative to the surface over which the carrier moves.

**[0015]** In a further aspect, the carrier further comprises an accelerometer configured to detect a motion of the carrier relative to the surface over which the carrier moves.

**[0016]** In some aspects of the carrier, the imaging sensor comprises a serial interface configured for communication with the processor.

**[0017]** In other aspects, the carrier further comprises an inductive sensor coupled to the processor and configured to detect the presence of said fastening elements in a magazine of the fastener driver. The processor may be configured to read and process a signal provided by inductive sensor for detecting the presence of fastening elements in the magazine.

**[0018]** In a further aspect, the carrier further comprises an onboard power source for supplying power to at least one of the imaging sensor, the processor and/or the memory unit.

**[0019]** In yet another aspect, the carrier further comprises a control panel for selecting a predetermined spacing between which the fastening elements are to be discharged from the fastener driver. The control panel may comprise a button for selecting the predetermined spacing between the fastening elements. The control panel may further comprise at least one light-emitting diode for indicating the selected predetermined spacing between the fastening elements.

**[0020]** In another aspect, the carrier further comprises at least one handle attached to the platform for enabling a user to push or pull the carrier over the surface to be fastened with fastening elements.

**[0021]** In a yet further aspect, the at least one motion element of the carrier is selected from the list comprising: a wheel, a castor, a belt tread, wear strip or other member with low friction.

**[0022]** It is a further object of the invention to provide a carrier for a fastener driver in which the discharging of fasteners at uniform or equally spaced intervals can be fully automated. According to another aspect, the carrier further comprises an activation means coupled to the processor and the fastener driver, wherein the signal generated by the processor is configured to trigger discharging of one or more fastening elements from the fastener driver.

**[0023]** In a further aspect, the activation means comprised in the carrier comprises an air actuator cylinder coupled to an air control valve which is controlled by the processor.

**[0024]** In other aspects, the carrier further comprises an indication means coupled to the processor, wherein the signal generated by the processor is configured to trigger the indication means in response to the carrier travelling a distance having a magnitude equal to or greater than the predetermined spacing value. In this way the user or operator receives an indication to discharge the fastener driver such that fastening elements are discharged at uniform and regular intervals according to the predetermined spacing value.

**[0025]** It is a further object of the invention to provide a fastener driving system which includes a fastener driver and the carrier according to the first aspect described above, in which the uniformly spaced intervals with which fastening elements are discharged from the fastener driver can be conveniently set in advance and easily modified without changing a structural element of the carrier. In a further aspect of the second aspect, fastener driver comprises one of a nail gun, a stapler and/or a screwdriver and said fasteners comprise nails, staples and/or screws, respectively. In yet a further aspect of the second aspect above, the fastener driver of the fastener driving system may comprise a magazine of fastening elements.

**[0026]** In a further aspect to the second aspect above, the carrier further comprises an inductive sensor coupled to the processor and configured to detect the presence of said fastening elements in a magazine of the fastener driver.

**[0027]** It is a further object of the invention to provide a method for using the fastener driving system according to the second aspect, such that fastening elements are discharged into a surface at uniformly spaced intervals.

**[0028]** Accordingly, in another aspect, a method is provided for discharging fastening elements at uniformly spaced intervals from a moving fastener driving system, for instance the fastener driving system described above. The method includes the steps of receiving a predetermined fastener spacing value, obtaining a displacement value from an imaging sensor in response to movement of the fastener driver system over a surface, calculating a distance traversed by the moving fastener driving system based on the obtained displacement value, comparing the calculated distance with the predetermined fastener spacing value and generating a signal in response to the calculated distance having a magnitude equal to

or greater than the predetermined fastener spacing value. The predetermined fastener spacing value corresponds to the uniform spacing of fastening the elements. The method is amenable to execution by any computer processing apparatus, e.g., a processor and thus is a computer-implemented method.

**[0029]** In a further aspect, the step of receiving a predetermined fastener spacing value comprises fetching the predetermined fastener spacing value from memory.

**[0030]** In some aspects, the step of receiving a predetermined fastener spacing value comprises reading a user-selected fastener spacing from a control panel of the fastener driving system.

**[0031]** The method of claim N further comprising the step of detecting whether the fastener driving system has moved over the surface.

**[0032]** The method of claim N wherein the step of calculating the distance traversed by the moving fastener driving system comprises adding consecutive displacement values obtained from the imaging sensor

**[0033]** In a preferred aspect, the generated signal is used as an activation signal and the method further comprises the step of triggering the discharge of fastening elements from the fastener driving system via the activation signal and an activation means.

**[0034]** In some aspects, the method further comprises the steps of receiving a signal from an inductive sensor configured to detect presence of the fastening elements in a magazine of the fastener driver and in response to the signal indicating that the magazine of the fastener driver is empty of fastening elements, generating an alert. The alert signals to the user that the magazine of fasteners is empty and thus the automatic discharge of fastening elements at predetermined fastener spacing is not possible.

**[0035]** In a further aspect, a computer program comprising instructions is provided which, when the program is executed by a processor, cause the processor to perform the method described above.

**[0036]** In a yet a further aspect, a computer-readable storage medium is provided comprising instructions stored thereon which, when executed by a processor, cause the processor to perform the method of any one of claims 14 to 16.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0037]** The invention will be more fully understood with reference to the detailed description given herein below and the accompanying drawings in which:

**Fig.** 1 shows a block diagram illustrating a plan view of the carrier for use with a fastener driver according to one aspect of the present invention.

**Fig.** 2 shows a block diagram illustrating a plan view of the fastener driving system according to one aspect of the present invention.

**Fig.** 3 shows a schematic flow diagram illustrating a method for discharging fasteners using the fastener driving system according to one aspect of the present invention.

**[0038]** Elements in the figures are illustrated for simplicity and clarity, and thus have not necessarily been drawn to scale. Furthermore, the use of dotted or dashed lines in the drawings indicate optional features and/or steps. It is further noted that the invention as disclosed in the accompanying drawings is illustrated by way of example only and therefore should not be considered as limiting the claimed invention.

## DETAILED DESCRIPTION

**[0039]** Various aspects of the invention will now be described with reference to the drawings, wherein like or similar reference numerals represent like or similar elements throughout the various drawing figures.

**[0040]** As illustrated in **Fig. 1**, one aspect of the present invention is directed to a carrier 100 for use with a fastener driver. Typically, the fastener driver (not shown in **Fig. 1**) will be securely mounted onto the carrier 100. However, the carrier 100 can be manufactured and sold independently of the fastener driver. In some embodiments, the carrier 100 is designed and configured for a particular off-the-shelf fastener driver type, make or model. In other embodiments, the carrier 100 is not dedicated to a specific type, make or model of the fastener driver. In other words, in some embodiments the carrier 100 is configured as a generic carrier suitable for use with as many different types, makes and models of fastener drivers as possible.

**[0041]** The carrier 100 includes a platform 110, at least one motion element 120 coupled to the platform, an imaging sensor 130 for detecting motion of the carrier 100, a processor 140 in communication with the imaging sensor 130 and a memory unit 150 coupled to the processor 140. In some embodiments, the carrier 100 may also include an onboard power source 160 for supplying power to the imaging sensor 130, processor 140 and/or memory unit 150. The power source 160 may be a battery, however other means such as a fuel cell and/or solar unit, may also be used to power the imaging sensor 130, processor 140 and/or memory unit 150. In other embodiments, an onboard power source is not provided. For instance, power may alternatively be supplied externally by means of a suitable long power cable connected to the carrier 100. Thus, provision of the power source 160 described above is optional.

**[0042]** In some embodiments, the carrier 100 may also include an activation means 170 for triggering the fastener driver to discharge or 'fire' one or more fasteners. As shown in **Fig.1**, the activation means is coupled to the processor 140 by wired or wireless means. As later described below, the activation means is configured to receive a signal from the processor 140 in order to 'trig-

ger' the discharge of fastening elements from a fastener driver. In other embodiments however, the activation means 170 may be part of or integrated into the fastener driver and therefore not included in the carrier 100. The use of dashed/dotted lines to depict the activation means 170 indicate that the presence of this component on the carrier is entirely optional.

**[0043]** The platform 110 directly or indirectly supports the weight of the fastener driver to be used with the carrier 100. The term platform may refer to a frame, a base, a plate, a support or any other mechanical structure suitable for supporting the fastener driver. The skilled person will understand that the platform 110 can take on many different shapes or forms, depending on the application of the carrier 100 and the fastener driver used with the carrier 100.

**[0044]** The carrier 100 includes at least one motion element 120 coupled to the platform 110 to raise the carrier 100, enabling it to travel across a surface 180 to be fastened. The carrier 100 may include without limitation one or more further motion elements 120 supporting the platform 110 of the carrier to which the fastener driver is attached for movement over the surface 180. For example, the carrier 100 depicted in **Fig. 1** has four motion elements 120a, 120b, 120c, 120d coupled to the platform 110. However, the skilled person will appreciate that, depending on the application, one, two or three motion elements could be coupled to the platform 110 and support the carrier 100 for motion across the surface 180. It should be further noted that the motion elements 120a, 120b, 120c, 120d shown in **Fig. 1** could alternatively be coupled to the top and bottom side of the platform 110, thereby allowing horizontal (left-right) motion of the carrier 100 instead of vertical (up-down) motion.

**[0045]** Motion elements, such as rollers, casters or wheels, provide smooth movement over the surface 180 and are thus preferred. However, other well-known elements can instead be used for the motion elements 120a, 120b, 120c, 120d to support the carrier 100 above the surface while permitting translation of the fastener driver used with the carrier 100. One of the advantages of the present invention is activation of the fastener driver doesn't require heavy mechanical means such as a cam wheel or the like for sensing the distance travelled through rotation of a wheel. Not only does this minimise the number of moving parts, the simpler and lighter structure means that alternate elements such as belt treads, wear strips or members having low friction may be used as motion elements 120a, 120b, 120c, 120d. In other words, rotational motion elements are not strictly essential.

**[0046]** The imaging sensor 130 is attached to the platform 110 and is configured for detecting a motion of the carrier 100 relative to the surface 180 over which the carrier 100 travels. Imaging sensors which are capable of detecting displacements are well known in the art. Some imaging sensors work by illuminating the surface 180 over which they travel with a light source such as a laser. By capturing the reflected light returned from the surface 180 and outputting an image frame, a processing unit in the imaging sensor 130 is able to calculate a displacement according to a window of interest in the image frame. Such imaging sensors provide a wide depth of field range and are relatively accurate in measuring displacement. Further such sensors do not require an optical lens and thus are compact and reliable. An example of such an imaging sensor is the PAT9136E1-TXQT Optical Tracking Sensor Chip from PixArt Imaging Inc.

**[0047]** Preferably, the imaging sensor 130 is attached to the platform 110 such that the sensing side of the imaging sensor 130 faces the surface 180 to be sensed, i.e. is downward facing. However, the skilled person will appreciate that other orientations are possible, especially if optical elements such as mirrors and/or lenses are deployed. After calculating a new displacement, the imaging sensor 130 stores information relating to the displacement, for example a change in position along the longitudinal axis (delta x) or a change in position along the lateral axis (delta y). This information can be read for example from a dedicated register provided by the imaging sensor. The imaging sensor 130 may also provide status information indicating when it has detected movement and new information generated from the movement is available.

**[0048]** The carrier 100 additionally includes a processor 140. The skilled person will appreciate that the processor 140 may take, without limitation, various forms such as a microcontroller, microprocessor, general purpose controller or mini computer. For instance, the processor 140 may be a HC11 microcontroller, e.g., M68HC11E from NXP. The processor 140 is coupled to a memory unit 150 which may be one or more of a RAM, ROM, EPROM, flash or other conventional forms of memory. The memory unit 150 may store data and/or a program comprising instructions for execution on the processor 140.

**[0049]** The memory unit 150 may store in non-volatile memory a predetermined spacing value with which fasteners are discharged from the fastener driver. Essentially the spacing value corresponds to a distance measurement and may be provided in units of millimetres, centimetres, metres or feet. The predetermined spacing value may, for example, be fetched from the memory unit 150 and transferred to a register within the processor 140 upon power up. This has the advantage that no addition hardware is required with the downfall that a fixed value of fastener spacing is always used to discharge the fasteners.

**[0050]** In another aspect of the present invention, the carrier 100 may further include a control panel 198 for allowing a user to select the value of the predetermined spacing with which to discharge fasteners. The values may be selected via a button 192 mounted on the control panel 198 which toggles two or more different spacing value selections. Alternatively, a button 192 for each predetermined fastener spacing value may be provided on

the control panel 198 so that the user only needs to depress the button corresponding to the desired predetermined fastener spacing. Alternatively, a graphical user interface or GUI 194 may be provided on the control panel 198 which prompts the user of the carrier 100 to insert a desired predetermined fastener spacing value. The processor 140 may store the predetermined fastener spacing value entered into the GUI 194 in the memory unit 150. The stored value may overwrite a pre-existing value stored in the memory unit 150 or may be stored alongside one or more previously stored values which can be later selected from via the GUI 194.

**[0051]** To indicate which predetermined fastener spacing value has currently been selected, the control panel 198 may optionally include one or more light-emitting diodes or LEDs 196 mounted on the control panel 198. Preferably, one LED 196 per predetermined fastener spacing option may be provided. The skilled person however would quickly appreciate that one LED 196 could be used to indicate different fastener spacing selections by flashing at different rates, e.g. low rate of blinking means a smaller selected spacing, while a high blinking rate could indicate a larger selected fastener spacing.

**[0052]** The processor 140 is further configured to also be in communication with the imaging sensor 130. As shown in **Fig. 1**, communication may take place, for example, over an interface. A serial interface, e.g. a serial port interface (SPI), or a parallel port interface may be used for the communication between the processor 140 and the imaging sensor 130. The serial interface may be located in the imaging sensor 130 and/or the processor 140. In one aspect of the present invention, a serial interface for communication with the processor 140 is located in the imaging sensor 130.

**[0053]** In another aspect, the processor 140 is configured to be in communication with the imaging sensor 130 using a wireless means of communication such as Bluetooth, NFC, 802.11, or another wireless technology. Thus, in this aspect, the imaging sensor 130 and the processor 140 are not physically connected and hence may be located on separate printed circuit boards (PCB) on the carrier 100.

**[0054]** While the imaging sensor 130 detects the displacement undergone by the carrier 100 as a result of movement and provides this at an internal location, e.g. register, that can be read from outside, the processor 140 is configured to read the displacement value from the imaging sensor 130 and compute the total distanced travelled by the carrier 100 based on the read displacement value. To accomplish this, the processor 140 adds, sums or integrates each displacement value read from the imaging sensor 130 to obtain the total distanced travelled by the carrier 100 over the surface it moves. The processor 140 is configured to compare the total distanced travelled calculated with the predetermined fastener spacing value. The predetermined spacing value of the fasteners may be stored locally in a register or in the memory unit 150. When the total distance travelled calculated by the processor 140 equals or exceeds the predetermined fastener spacing stored in memory or the register, the processor 140 is configured to generate a signal as described below in reference to **Fig. 3.**

**[0055]** In some embodiments, the carrier 100 includes an inductive sensor 175 mounted to the platform 110. Inductive sensors use the principle of electromagnetic induction to detect metal objects located in their electromagnetic field. In this way, the inductive sensor can be used to detect the presence of metal fasteners within their proximity. For instance, inductive sensor 175 could be used to detect metal fasteners associated with a fastener driver (not shown) when mounted on the carrier 100 which is explained in more detail below. As shown in **Fig. 1**, inductive sensor 175 is configured to be in communication with the processor 140, either by wired or wireless means. Furthermore, the processor 140 is additionally configured to read and process a signal provided by the inductive sensor 175.

**[0056]** Optionally, the carrier 100 may further include one or more handles (not shown in **Fig. 1**) coupled to the platform 110 to facilitate conveyance of the carrier 100 over the surface 180 to be fastened. In this way, a user may more conveniently push or pull the carrier 100 over the surface 180. Without the one or more handles, movement of the carrier 100 is however still possible. For example, the user may push or pull the carrier 100 from a convenient location on the platform 110. Alternatively, the carrier 100 may further comprise a means, such as a motor, for automatically propelling the carrier 100 in the direction of travel. The movement of the carrier 100 may be controlled via the optional control panel 198 comprised within the carrier 100.

**[0057]** In one aspect, the fastener driver used in conjunction with the carrier 100 may be automatically triggered to drive fasteners at uniformly spaced intervals using an activation means 170 further comprised in the carrier 100. In this case, the processor 140 is further configured to control the activation means 170, for example by a signal produced by the processor 140 and relayed to the activation means 170. The signal may be relayed by wired or wireless means, i.e. a physical connection between the processor 140 and the activation means 170 is not necessary. The activation means 170 is coupled to the fastener driver. In this way, the activation means 170 may then transmit a pneumatic, hydraulic, electrical, or magnetic signal to trigger the fastener driver to discharge fasteners. If a pneumatic signal is used to trigger the fastener driver, the activation means 170 may further comprise an air actuator cylinder coupled to an air control valve (not shown in **Fig. 1**). In this way, the air actuator cylinder and the air control valve are controlled by processor 140.

**[0058]** However, the activation means 170 is not essential. In another aspect, an indication means (not shown in **Fig. 1**) instead of activation means 170 is comprised in the carrier 100. The indication means may be provided in a number of different ways, including without

limitation, a visual means, an audio means or other known means in the art. Regardless of the specific implementation, the indication means is used to indicate to an operator or user of the fastener driver with carrier 100 that the fastener driver has reached a location where the discharging of the driver would discharge a fastener having a predetermined spacing with respect to a previously discharged fastener. For example, a light-emitting diode or other visual indicator could be used to indicate that a fastener is to be discharged. In other embodiments, an audio device, such as a speaker could emit a tone, beep, or similar to indicate that the fastener driver is at a position according to the predetermined fastener spacing. The operator of the equipment could then manually or otherwise discharge the fastener driver based on the provided indication. In contrast to the previous aspect, this provides a semi-automatic mode of discharging fasteners having uniformly-spaced intervals. In other words, manual intervention is needed to activate the fastener driver such that fasteners are finally discharged.

**[0059]** As shown in **Fig. 2**, another aspect of the present invention is directed to a fastener driving system 205 which includes a carrier 200 and a fastener driver 290 mounted onto the carrier 200. The fastener driver 290 comprises a magazine 295 for storing the fasteners to be discharged by the driver. The fastener driver 290 may also comprise a power source (not shown), e.g. a battery pack, for supplying power to the driver when in use. The carrier 200 includes a platform 210, at least one motion element 220 coupled to the platform, an imaging sensor 230 for detecting motion of the carrier 200, a processor 240 in communication with the imaging sensor 230 and a memory unit 250 coupled to the processor 240. In **Fig. 2**, four motion elements 220a, 220b, 220c, 220d are illustrated however the skilled person will appreciate that, depending on the application, one, two or three motion elements could be coupled to the platform 210 to support the carrier 200 for motion across a surface 280 to be fastened. The carrier 200 is similar to the carrier 100 described in relation to **Fig. 1**, and thus a detailed description thereof will be omitted herein to avoid unnecessary repetition. For instance, control panel 298 is substantially identical to control panel 198 on carrier 100 and is also optional just like control panel 198. The aspects mentioned above in relation to carrier 100 equally apply to carrier 200 of the fastener driving system 205. Only where aspects may differ, will they be described below.

**[0060]** As with carrier 100, carrier 200 may further include, without limitation, an onboard power source 260 such as a battery, fuel cell and/or solar unit. The skilled person will appreciate however that other implementations are possible, for instance, in other embodiments the carrier 100, 200 may source power from external means and thus power source 260 is entirely optional. In addition to supplying power to the imaging sensor 230, processor 240 and/or memory unit 250, the power source 260 may be adapted to also supply power to the fastener driver 290. In other embodiments, the fastener driver 290 is powered by pneumatic or hydraulic means and thus the carrier may be adapted to receive pressured air or liquid under pressure from external means by way of hoses or similar.

**[0061]** The fastener driver 290 may be an off-the-shelf fastener driver of the handheld type. Thus, the fastener driver may be removably attached to the carrier 200 so that the fastener driver 290 may be exchanged with another fastening tool. The carriage 200 may further include securing means (not shown in **Fig. 2**) to ensure the fastener driver 290 is securely mounted to the platform 210 of the carrier 200. Such securing means may include a bracket, clamp, bolts or other mechanical means with which to securely fasten the fastener driver 290 to the platform 210.

**[0062]** The fastener driver 290 of the fastener driving system 205 can be any number of different devices well known to those skilled in the art for driving fasteners, including without limitation staplers, nail guns, drilling machines with a magazine screwdriver attachment and the like operable electrically, electro-magnetically, hydraulically, pneumatically or otherwise. Accordingly, the fasteners discharged by the fastener driver 290 can be a number of different fastening elements, including without limitation staples, nails, screws and other fastening elements known in the art. The skilled person would face no difficulty making the necessary adjustments to the carrier 200 and/or platform 210 to accommodate the particular fastener driver 290 chosen.

**[0063]** The use of the fastener driving system (205) to discharge fastening elements such as nails, staples, screws, etc. will now be described. The user first prepares, i.e. arranges the two or more materials to be fastened together. Then the user prepares the fastening driving system by ensuring that the magazine 295 of the fastener driver 290 is loaded with fastening elements. In some embodiments, preparation may also include securing the pneumatic supply and/or power supply - if optional power supply 260 is not present - to the system 205 and turning on the power supply.

**[0064]** Next the user selects the spacing distance in which to uniformly disperse or discharge the fastening elements by pressing the push button 292 on the control panel 298. Where the fastener driving system is already pre-programmed to discharge the fasteners at the desired spacing, this step can be skipped. Following selection of the desired spacing, the user then slowly leads the fastener driving system 205, i.e. pushes or pulls the carriage, e.g. via the handle if it is present, across the surface to be fastened with fastening elements, ensuring that the carriage runs straight over the area to be fastened. If the fastener driving system 205 comprises activation means 270 then the fastening elements will be automatically discharged into the surface to be fastener. On the other hand, if the fastening driving system 205 comprises indication means instead of activation means 270, the fastener driving system 205 will indicate, e.g. by visual, audio, vibration or other means via the control

panel 298 when the fastener driver will need to be manually triggered by the user to discharge the fastening elements. In either case, the fastening elements will be uniformly placed at the desired spacing into the one or more materials to be fastened.

**[0065]** Preferably, the carrier 200 is adapted to hold the fastener driver such that the fastener driver's barrel is orientated downwards. In this way, the fasteners can be discharged into the surface 280, e.g. a roof or floor, over which the carrier 200 is moved. Hence the fasteners are driven into the surface transversally to the direction of travel of the carrier 200. The skilled person will quickly appreciate that the fasteners need not be discharged in a direction orthogonal to the direction of travel. For instance, the fastener driver 290 may be supported at an angle with respect to the surface 290 over which the carrier 200 travels so that fasteners are discharged at an angle or slant to the normal axis.

**[0066]** In some embodiments, the carrier 200 includes an inductive sensor 275 mounted to the platform 210. Preferably, the inductive sensor 275 is mounted near the magazine 295 comprised in the fastener driver 290. In this way, the inductive sensor 275 can be used to detect the presence of metal fasteners in the magazine 295 of the fastener driver 290. In particular, the inductive sensor 275 can detect when the magazine 295 is empty and thus, the driver 290 is unable to discharge fasteners, e.g., staples, nails, etc., into the surface 280 of the material to be fastened. As shown in **Fig. 2**, inductive sensor 275 is configured to be in communication with the processor 240, either by wired or wireless means. Furthermore, the processor 240 is additionally configured to read and process a signal provided by the inductive sensor 275.

**[0067]** The procedure or process for discharging fasteners at uniformly spaced intervals from a fastening system, for example from the fastener driving system 205 discussed previously with reference to **Fig. 2**, is further explained with reference to method 300 in **Fig. 3.**

**[0068]** The method begins with step 305 which comprises housekeeping operations in the processor 140, 240 such as fetching data and/or instructions from memory and/or initialising registers within the processor 140, 240. The instructions or computer program code are stored in memory, such as the memory unit 150, 250. In a preferred embodiment, the instructions are stored on non-volatile memory and executed by the processor 140, 240 according to the following steps.

**[0069]** At step 310, a predetermined spacing value of the fasteners to be discharged by the fastener driver is retrieved from memory. This memory may be memory unit 150, 250 or alternatively may be a memory, e.g. a register, within the processor 140, 240. In steps 315 -320 a determination is made whether the fastener driving system 205 has moved relative to the surface 180, 280 on which the carrier 100, 200 of the fastener driving system 205 is placed. The movement maybe determined in a number of different ways. For instance, a dedicated sensor (not shown in **Fig. 1** and **Fig. 2**), e.g. an accelerometer, may be placed on the carrier 100, 200 and coupled to the processor 140, 240 to determine a motion status of the carrier 100, 200 and thus the fastener driver system 205. Alternatively, the imaging sensor 130, 230 may provide its own means to sense motion of the carrier 100, 200. For instance, the imaging sensor 130, 230 may provide a status register indicating a motion status ('motion status register') which may read by the processor 140, 240 during step 315 to determine the motion status.

**[0070]** If the dedicated motion sensor, e.g. the accelerometer, or the motion status register of the imaging sensor 230 indicates that there has been no movement, e.g. a motion bit of the imaging sensor 230 is set to logic 'low', the method returns to step 315. In one aspect, the method may proceed to optional steps 355 - 365 if motion is not detected in step 320 . If a predetermined fastener spacing selection is provided, e.g. via the optional control panel 198, 298, the processor 120, 240 reads a spacing selector in a step 355. In a step 360, a determination is made whether a selector bit has been set to logic 'high'. If the selector bit is not set to logic 'high' = 1, in other words, is set to logic 'low' = 0, the processor 140, 240 returns to step 315 to determine a motion status of the fastener driver system 205. This implies that the fastener spacing to be applied has not changed. If on the other hand the selector bit 'Select' is set to logic 'high' = 1, this indicates that the desired fastener spacing has been changed by the user. In this case the new spacing value is selected in a step 365. This step may include storing the selected spacing value to the memory unit 150, 250 as part of step 365. For example, the previously stored value of the spacing value may be overwritten.

**[0071]** On the other hand, if the dedicated motion sensor, e.g. the accelerometer, or the motion status register of the imaging sensor 130, 230 indicates that the imaging sensor 130, 230, and therefore that the fastener driving system 205, has moved, e.g. a motion bit may be set to logic 'high' = 1 as shown in a step 320 to indicate sensed motion, the method proceeds to step 325 where the processor 240 reads a displacement value along one or more of an x-axis (delta x) or a y-axis (delta y) which the imaging sensor 130, 230 outputs in response to the detected movement.

**[0072]** At step 330 the processor 140, 240 calculates a distance travelled by the fastener driving system 205 by adding, accumulating or integrating the read displacement value just read, i.e. one or more of delta X and or delta Y to a register which is used to keep a running sum of the displacement of the imaging sensor 130, 230 and therefore the fastening system, e.g. fastener driving system 205. In essence, the running sum of displacements is a measurement of the total distance traversed by the imaging sensor 130, 230 and, by association, the carrier, e.g. carrier 200 whereon the fastener driver, e.g. fastener driver 290 is mounted. The skilled person will appreciate that the register storing the running sum will initially be zero as a result of initialisation the first time the program stored in the memory runs.

**[0073]** In a next step 335, the processor compares the value of the running sum stored in the register with the predetermined fastener spacing value retrieved from memory at step 305. If it is determined in step 340 as a result of this comparison that the running sum is less than the predetermined spacing value, program control passes back to step 315 where the processor 240 waits for a indication that the imaging sensor 130, 230 or dedicated sensor, e.g. accelerator (not shown) has detected movement. On the other hand, if in step 340 it is determined, as a result of the comparison, that the running sum stored in the register as a result of step 330 is greater than or equal to the value of predetermined fastener spacing retrieved from memory in step 310, or selected and stored in step 365, program control jumps to a step 345 which comprises generating a signal. After the signal has been generated, the processor, e.g. for example processor 240 of the fastener driving system 205, resets the register holding the value of the running sum in a step 350 so that the process can start over again from step 315.

**[0074]** In one aspect (not shown in **Fig. 3**), the generated signal is used to automatically trigger the fastener driver, e.g. fastener driver 290 depicted in **Fig. 3**, so that it discharges or fires a fastener, e.g. nail, staple, screw, etc., into the surface 280 of the material to be fastened. This step may involve passing the activation signal generated from the processor to a means for activating the fastener driver, e.g. optional activation means 170, 270 of **Fig. 1**, **Fig. 2**, respectively. As described above, the activation means may be carried out, without limitation, via electrical, pneumatic, magnetic or hydraulic means. In this way, the method provides an automatic mode of operating the fastener drive such that fasteners are released at uniformly spaced intervals.

**[0075]** In some embodiments, where the optional inductive sensor 175, 275 is present, the method 300 further comprises optional steps 342 - 344 which will be now described. Returning to step 340, if in step 340 it is determined, as a result of the comparison performed in step 335, that the running sum determined in step 330 is greater than or equal to the value of predetermined fastener spacing, program control is passed to step 342. In step 342, the processor 140, 240 reads the signal provided by the inductive sensor 175, 275 and sets a register bit, i.e. 'empty' bit to logic 'high' = 1, if the signal from the inductive sensor 175, 275 indicates that the magazine 295 of the fastener driver 290 is empty. If on the other hand, if the read inductive sensor signal indicates that the magazine 295 of the fastener driver 290 is not empty, i.e. the 'empty' bit is set to logic 'low' = 0.

**[0076]** In case the 'empty' bit is set to logic 'high' = 1, program control passes to step 344 in which method 300 stops and processor 140, 240 generates an alert. If however, the 'empty' bit is set to logic 'low' = 0, program control proceeds to step 345 and results in generation of the activation signal as described before. The skilled person will appreciate that while steps 342 - 344 are executed after step 340 in **Fig. 3**, these steps could be executed earlier in the shown sequence of method 300. For example, the processor 140, 240 could be configured to read the inductive sensor 175, 275 (step 342 shown in **Fig. 3**) immediately after motion of the carrier 100, 200 has been determined in step 320, i.e. the motion bit has been set to logic 'high' = 1. The skilled person will realise however, that other placements of steps 342 - 344 in the sequence of method 300 are possible.

**[0077]** In another aspect (also not shown in **Fig. 3**), the generated signal is used to indicate to a user operating the fastener driving system 205, e.g. via indication means (not shown in **Fig. 2**), that the position of the carrier, e.g. carrier 200 of the fastener driving system 205, is such that the predetermined fastener spacing of fasteners has been reached. This may be indicated in several different ways, including without limitation, visual means, audio means or other known means in the art. For example, a light-emitting diode or other visual indicator could be used to indicate that a fastener is to be discharged. In other embodiments, a audio device, such as a speaker could emit a tone, beep, or similar to indicate that the system comprising the fastener driver, e.g. fastener driving system 205, is at a position according to the predetermined fastener spacing. The operator of the equipment could then manually or otherwise discharge the fastener driver based on the indication. In contrast to the previous aspect, this provides a semi-automatic mode of discharging fasteners having uniformly spaced intervals.

**[0078]** Although the present invention has been described with reference to different aspects, workers skilled in the art will recognize that changes may be made in form and detail which still fall under the scope of the claims attached herein.

## Claims

**1.** A carrier (100, 200) for use with a fastener driver (290), the carrier (100, 200) comprising:

- a platform (110, 210) for supporting the fastener driver (290);
- at least one motion element (120a, 120b, 120c, 120d, 220a, 220b, 220c, 220d) coupled to said platform (110,210) and supporting the carrier (100, 200) for motion over a surface (180, 280) to be fastened;
- an imaging sensor (130, 230) attached to said platform (110, 210) and configured to determine and output values of displacement traversed by said carrier (100, 200) as it moves over the surface (180, 280); and
- a processor (140, 240) operably coupled to said imaging sensor (130, 230), and configured to receive the said displacement values and calculate based thereon a distance traversed by the carrier (100, 200), wherein the processor (140, 240) is further configured to compare the

calculated distance with a predetermined spacing value and generate a signal in response to the calculated distance having a magnitude equal to or greater than the predetermined fastener spacing value. The predetermined spacing value corresponds to the spacing with which fastening elements are to be discharged from the fastening driver (290) and thus the pitch of the fastening elements in the fastened surface.

**2.** The carrier of claim 1, wherein said imaging sensor (130, 230) is an optical tracking sensor and comprises a laser.

**3.** The carrier of claim 1 or 2 further comprising a memory unit (150, 160) coupled to the processor wherein the predetermined fastener spacing value is stored in the memory unit.

**4.** The carrier of any one of the preceding claims, wherein the imaging sensor comprises a serial interface configured for communication with the processor.

**5.** The carrier of any one of the preceding claims further comprising a control panel (198, 298) for selecting a predetermined spacing between which the fastening elements are to be discharged from the fastener driver (290).

**6.** The carrier of any one of the preceding claims further comprising an activation means (170, 270) coupled to the processor and the fastener driver (290), wherein the signal generated by the processor is configured to trigger the discharge of one or more fastening elements from the fastener driver.

**7.** A fastener driving system (205) comprising the fastener driver (290) and carrier (100,200) according to any one of claims 1 to 6.

**8.** The fastener driving system (205) of claim 7 wherein the carrier (100, 200) further comprises an inductive sensor (175, 275) coupled to the processor and configured to detect the presence of said fastening elements in a magazine (295) of the fastener driver (290).

**9.** The use of the fastener driving system (205) of claims 7 and 8 for discharging fastening elements into a surface at uniformly spaced intervals.

**10.** A method (300) for discharging fastening elements at uniformly spaced intervals from a moving fastener driving system, particularly the fastener driving system (205) of claims 7-8, the method comprising the steps of:

- receiving (310) a predetermined fastener spacing value
- obtaining (325) a displacement value from an imaging sensor in response to movement of the fastener driver system over a surface;
- calculating (335) a distance traversed by the moving fastener driving system based on the obtained displacement value;
- comparing (335) the calculated distance with the predetermined fastener spacing value; and
- generating (345) a signal in response to the calculated distance having a magnitude equal to or greater than the predetermined fastener spacing value.

**11.** The method of claim 10 wherein the step of receiving (310) a predetermined fastener spacing value comprises fetching the predetermined fastener spacing value from memory (150, 250).

**12.** The method of claims 10 and 11 wherein the step of calculating the distance traversed by the moving fastener driving system (205) comprises adding consecutive displacement values obtained from the imaging sensor.

**13.** The method of any one of claims 10 to 12 wherein the generated signal is used as an activation signal and the method further comprising the step of:
triggering the discharge of fastening elements from the fastener driving system via the activation signal and an activation means.

**14.** A computer program comprising instructions which, when the program is executed by a processor, cause the processor to perform the method of any one of claims 10 to 13.

**15.** A computer-readable storage medium comprising instructions stored thereon which, when executed by a processor, cause the processor to perform the method of any one of claims 10 to 13.

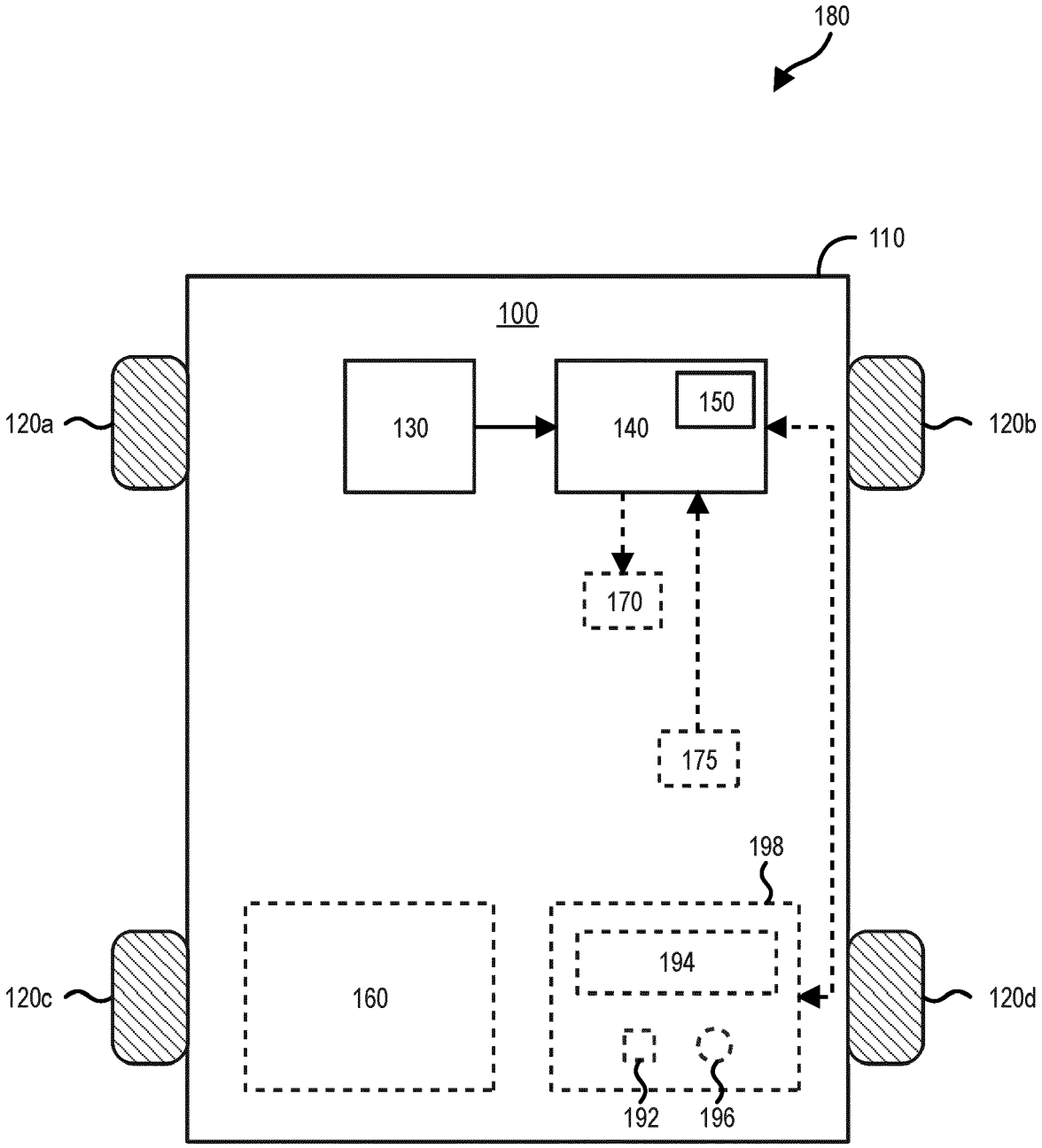
180
110
100
120a
130
140
150
120b
170
175
198
160
194
120c
120d
192
196

FIG. 1

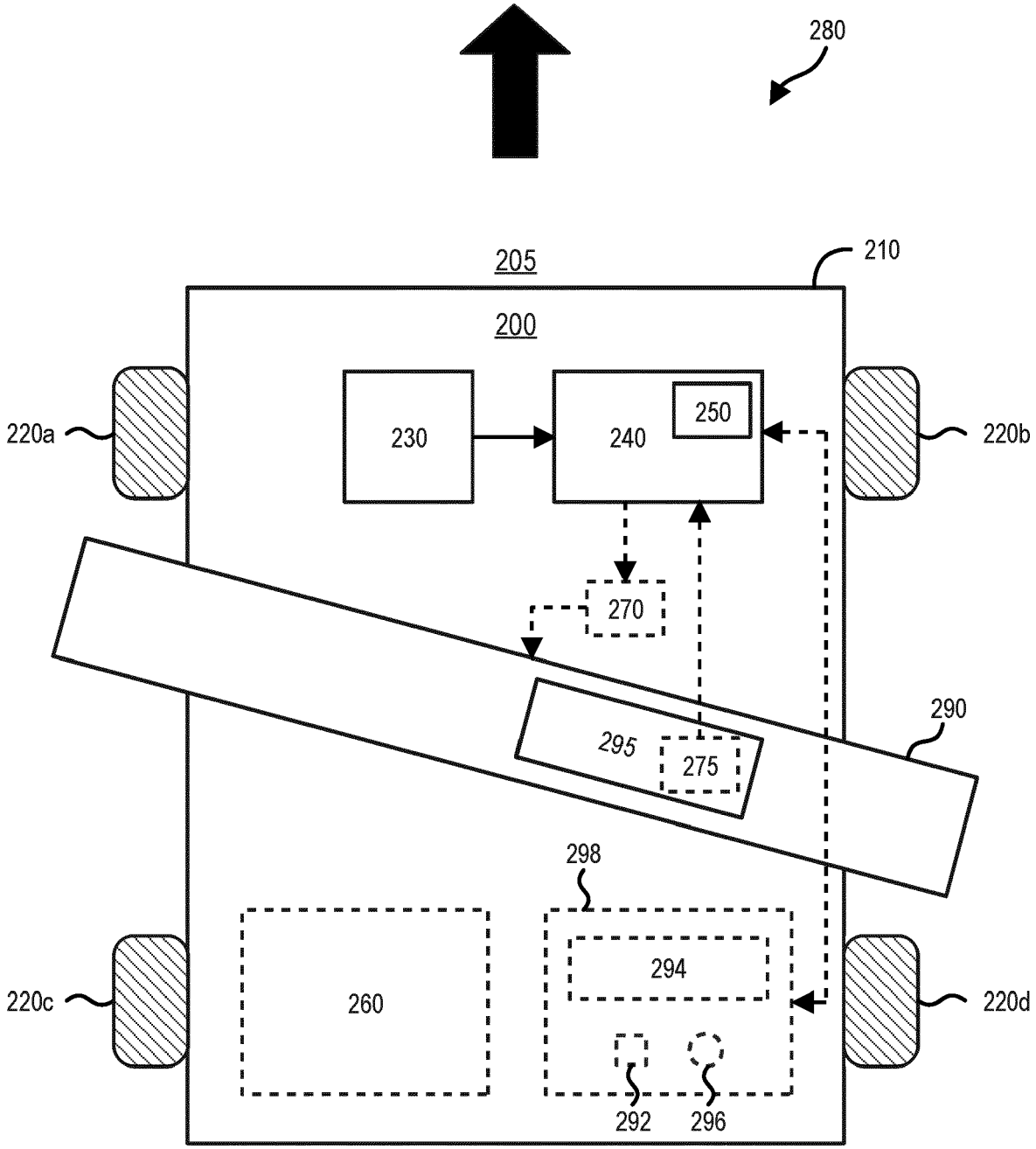
280
205
210
200
220a
230
240
250
220b
270
290
295
275
298
294
260
220c
220d
292
296

FIG. 2

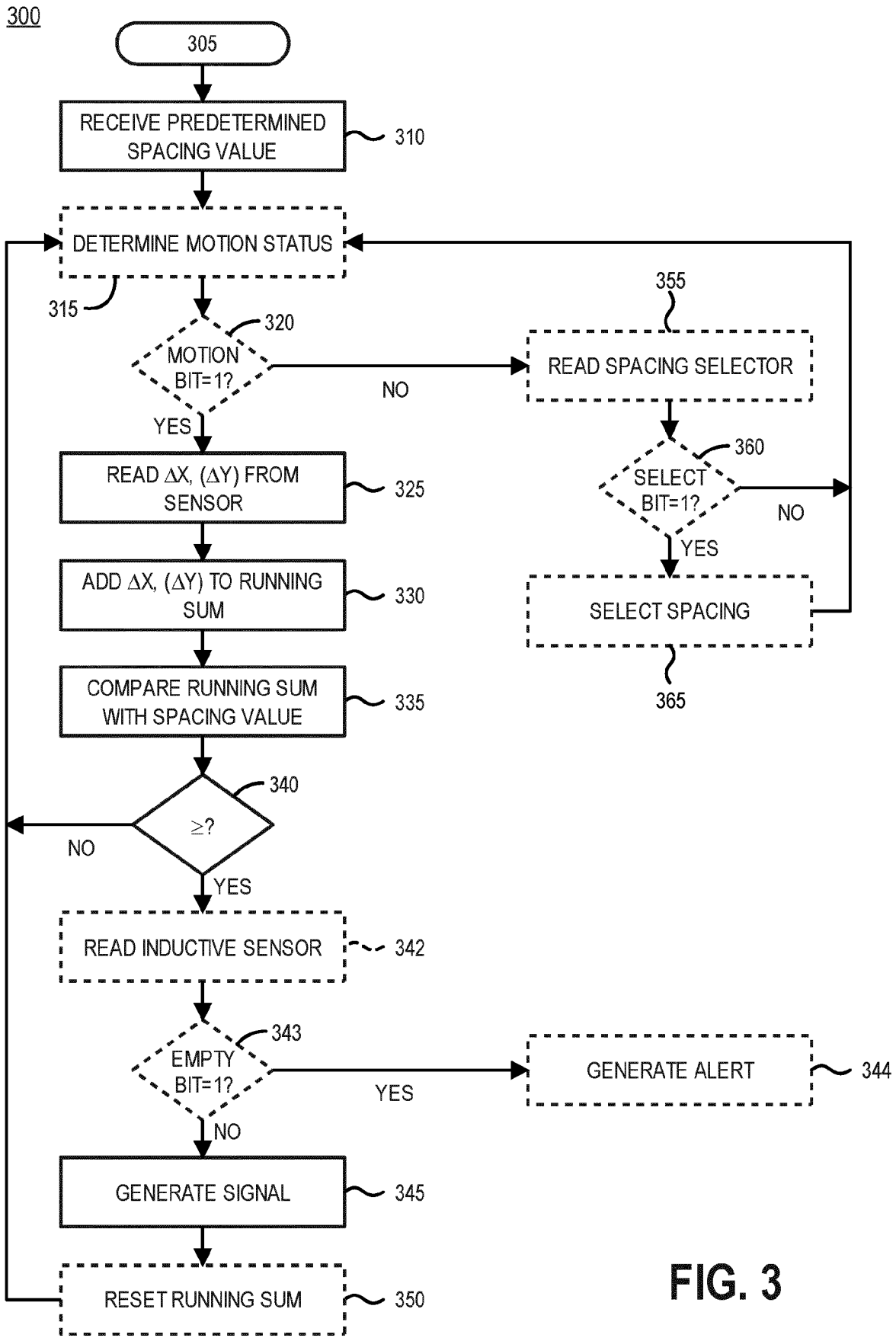
300
305
RECEIVE PREDETERMINED SPACING VALUE
310
DETERMINE MOTION STATUS
315
MOTION BIT=1?
320
NO
YES
READ ΔX, (ΔY) FROM SENSOR
325
ADD ΔX, (ΔY) TO RUNNING SUM
330
COMPARE RUNNING SUM WITH SPACING VALUE
335
≥?
340
NO
YES
READ INDUCTIVE SENSOR
342
EMPTY BIT=1?
343
YES
NO
GENERATE ALERT
344
GENERATE SIGNAL
345
RESET RUNNING SUM
350
355
READ SPACING SELECTOR
SELECT BIT=1?
360
NO
YES
SELECT SPACING
365

FIG. 3

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# EUROPEAN SEARCH REPORT

Application Number
EP 23 20 3100

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| Place of search | Date of completion of the search | Examiner |
|---|---|---|
| The Hague | 23 April 2024 | Matzdorf, Udo |

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