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(54) BUILDING MAINTENANCE UNIT WITH ASSISTED CRADLE MOVEMENT

(57) A building maintenance unit (10) comprising a base (12), a first rigid arm (16), a second rigid arm (30), a rigid support element (38), a plurality of drives (44, 46, 48), and a control unit (50) wherein the control unit (50) is adapted, if the control unit (50) receives a movement command to move a cradle (40) of the building maintenance unit (10) from a present position to a new position, to send control signals such that the cradle (40) at least substantially maintains a constant orientation during a movement to the new position until the new position is reached. Further, a building (42) having a building front (60) and a building maintenance unit (10) is disclosed.

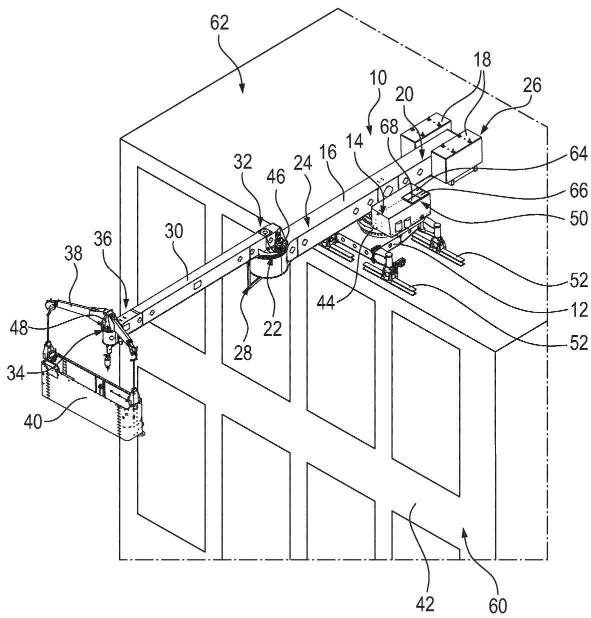

Fig. 1

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Description

Technical field

[0001] The present invention relates to a building maintenance unit for use in the maintenance of high-rise buildings.

Background information

[0002] Building maintenance units are a vital element for maintaining larger buildings, in particular high-rise buildings. One typical application building maintenance units is the cleaning of glass fronts of large buildings. Also, a potential need for repairs on the facade of large buildings can be addressed using building maintenance units.

[0003] A building maintenance unit is typically installed on a roof of a building. The building maintenance unit comprises an arm that can reach over the top edge of the building and lower a cradle to a desired position relative to the façade of the building.

[0004] Especially when a glass front of a building is to be cleaned, there is a pattern that is typically followed. The cleaning starts, e.g., at the top floor at a first side of the front and the cradle is successively lowered along the front, essentially performing a vertical downward movement. When a desired or allowed maximum downward travel is complete, the cradle maintaining height relative to the top floor. When the other side is reached, the cradle returns to the top floor and performs the next vertical downward movement that is offset horizontally from the previous vertical downward movement, and so on.

Brief summary

[0005] According to a first aspect of the invention there is provided a building maintenance unit comprising

- a base having a first pivot point,
- a first rigid arm mounted on the base and adapted to pivot around the first pivot point, the first arm having a first section of the first arm and having a second pivot point arranged on a second section of the first arm, wherein the first section is leading from the first pivot point to a first end of the first arm and the second section is leading from the first pivot point to a second end of the first arm opposite the first end,
- a second rigid arm arranged on the second pivot point with a third end of the second arm and adapted to pivot around the second pivot point, the second arm having a third pivot point at a fourth end of the second arm opposite the third end,
- a rigid support element arranged on the third pivot point and adapted to pivot around the third pivot point, the support element further adapted to carry a cradle for supporting workers and tools during maintenance of a building and adapted to lower and raise the cradle relative to the support element, wherein the support element and the cradle are linked such that a pivotal movement of the support element causes a concurrent pivotal movement of the cradle,
- a plurality of drives, wherein a first drive is adapted to move the first arm about the first pivot point, a second drive is adapted to move the second arm about the second pivot point, and a third drive is adapted to move the support element about the third pivot point, and
- a control unit adapted to send a first control signal to the first drive, the first control signal adapted to move the first arm, a second control signal to the second drive, the second control signal adapted to move the second arm, and a third control signal to the third drive, the third control signal adapted to move the third arm,

wherein the control unit is further adapted, if the control unit receives a movement command to move the cradle from a present position to a new position, to send first, second and third control signals such that the cradle at least substantially maintains a constant orientation during a movement to the new position until the new position is reached.

[0006] This allows for an intuitive control of the building maintenance unit without the need to understand the mechanical design and how the different drives work together. The user in the cradle steering the building maintenance unit can issue intuitive commands that lead to the intended movement. For example, if the user standing in the cradle intends to move the cradle forward, the cradle will move forward from the user's perspective and will maintain this orientation throughout the movement. This offers an additional safety for the operation of the cradle.

[0007] For the purpose of an improved balancing of the building maintenance unit, for preferred embodiments, a counter weight may be arranged on the first section of the first arm.

[0008] According to a preferred embodiment, the first control signal is adapted to move the first arm to a first pivot angle, the second control signal is adapted to move the second arm to a second pivot angle, and the third control signal is adapted to move the third arm to a third pivot angle.

[0009] According to another preferred embodiment, the first control signal is adapted to move the first arm at a first angular speed, the second control signal is adapted to move the second arm at a second angular speed, and the third control signal is adapted to move the third arm at a third angular speed.

[0010] This embodiment achieves a smooth movement. In order to determine the first, second and third control signals, the geometry of the building maintenance unit and the intended direction of travel of the cradle are taken into account. As two exemplary directions of travel, a movement of the cradle perpendicular to a reference plane and a movement of the cradle parallel to the reference plane. The reference plane is preferably a plane parallel to a building front or at least parallel to that section of the building front the cradle is currently facing.

[0011] In the following a preferred approach using a relative coordinate system is used that takes into account an angle the cradle may have relative to the base coordinate system in which an x-axis is orthogonal to the intended path of travel, a y-axis is parallel to the path of travel, and a z-axis is orthogonal to each of the x- and y-axis. It is understood that the relative coordinate system can be omitted and that all calculations can be performed within the base coordinate system.

[0012] As a non-limiting example, the base coordinate system may be chosen as follows: The x-axis may be perpendicular to an upper edge of a building on which the building maintenance unit is installed and over with edge the building maintenance unit reaches. Also, the x-axis may be perpendicular to rails on which the building maintenance unit is installed, the rails running adjacent the upper edge. The y-axis is perpendicular to the x-axis, i.e. parallel to the upper edge or parallel to the rails. The z-axis is perpendicular to the x-axis and the y-axis and parallel to the Earth's gravitational field. In other words, the z-axis is parallel to an up-down-direction. The origin of the base coordinate system may be located at the first pivot point.

[0013] The relative coordinate system is introduced with the consideration that a user in the cradle will naturally use the orientation of the cradle as the relative coordinate system. This means, a user in the cradle issuing a command for a movement to the left, expects the cradle to move to the left even if the cradle is oriented towards the building front at an angle. Or, if the user in the cradle issues a command for a backward movement, the user expects a backward movement from the cradle's viewpoint not from the buildings viewpoint.

[0014] First, a movement of the cradle perpendicular to the reference plane will be considered. As the relative coordinate system will be used in the following, the angle of the cradle relative to the base coordinate system is calculated and then, based on this angle, an angle of the first arm described in the relative coordinate system can be determined. Based on this information, the present xy-position of the cradle, more specifically of the third pivot point, can be determined.

[0015] Given the assumed orientation of the base coordinate system and relative coordinate system as described above, a perpendicular movement means that the y-coordinate is kept constant and that the cradle, more specifically of the third pivot point, moves along the x-axis in the relative coordinate system. Knowing the y-coordinate and the initial angle of the first drive, the angles of the second and third drives can be calculated.

[0016] In order to ease the understanding of the present invention, a further assumption is made, namely that the first drive moves at a constant angular speed. However, if needed, the calculations can also be performed based on a variable angular speed of the first drive. The calculations for the angles of the second and third drives can be performed for a first angle of the first drive that varies over time. Therefore, the first, second and third angles can be described as functions dependent on time (and the initial start values).

[0017] As it is deemed preferable to move the cradle by setting the speed of the plurality of drives, the derivative of the functions for the second and third angles provides the angular speeds at which the second and third drives have to be set to achieve the desired movement of the cradle. It is pointed out that the cradle can also be moved by successively defining xy-positions along the intended path and instructing the drives successively to move to new angular values for each corresponding xy-position in order to track the desired movement of the cradle.

[0018] Second, a movement of the cradle parallel to the reference plane will be considered. The approach to calculate the required angular speeds of the second and third drives, again, assuming for the ease of understanding that the first drive moves at a constant speed, is generally the same. However, for a parallel movement it is the x-coordinate that is kept constant and the cradle, more specifically of the third pivot point, moves along the y-axis in the relative coordinate system.

[0019] According to another preferred embodiment, the control unit is adapted to send the first, second and third control signals repeatedly.

[0020] This allows to send updated signals that are corrected according to an actual position of the cradle while it is moving. Also, this embodiment can be used to move the cradle in small steps along the intended path of travel.

[0021] According to another preferred embodiment, the first arm is adapted to pivot in a first plane and the second arm is adapted to pivot in a second plane, wherein the first plane is at least substantially parallel to the second plane.

[0022] This allows for a reliable execution of movements of the building maintenance unit. In particular, the first arm may be adapted to move only in the first plane and/or the second arm is adapted to pivot only in the second plane.

[0023] According to another preferred embodiment, the second arm is adapted to pivot in a second plane and the support element is adapted to pivot in a third plane, wherein the second plane is at least substantially parallel to the third plane.

[0024] This allows for a reliable execution of movements of the building maintenance unit. In particular, the second arm may be adapted to move only in the second plane and/or the support element is adapted to pivot only in the third plane.

[0025] According to another preferred embodiment, the support element is adapted to pivot in a third plane, wherein the support element is further adapted to lower and raise the cradle relative to the support element along an axis that is at least substantially orthogonal to the third plane.

[0026] This allows for a reliable execution of movements of the building maintenance unit, including the capability to move the cradle along a vertical axis, especially designated as the z-axis. In particular, the support element is adapted to pivot only in the third plane.

[0027] According to another preferred embodiment, the control unit comprises a programmable logic controller for calculating parameters for the movement of the cradle and/or a plurality of inverters for adjusting the movement of the plurality of drives.

[0028] This provides for a reliable and flexible design of the control unit.

[0029] According to another preferred embodiment, the control unit further comprises at least one sensor for monitoring one or more parameters from the group comprising position, speed and acceleration of the plurality of drives.

[0030] This allows for a closed-loop control, where the effect of the control signals can be continuously monitored via the sensors.

[0031] According to another preferred embodiment, the at least one sensor comprises one or more of absolute encoders, optical sensors and/or ultrasonic sensors.

[0032] These types of sensors are reliable and are also available as safety-certified versions.

[0033] According to another preferred embodiment, a control of the building maintenance unit is performed by a joystick, a button, or a human-machine interface communicatively linked to the control unit.

[0034] This allows for an intuitive movement of the cradle and reduces the risk of a human error when performing cradle movements.

[0035] According to another preferred embodiment, the control unit optimizes the use of power and other resources by adjusting the movement of the cradle.

[0036] According to another preferred embodiment, the base is arranged on rails that are adapted to be installed on a building and that are further adapted to allow for a movement of the base along the top of a building front of the building on which the building maintenance unit is installed.

[0037] This may allow for a movement of the cradle along the full width of the building front.

[0038] According to a second aspect of the invention, there is provided a building having a building front and a building maintenance unit as described above arranged on a roof section of the building such that the cradle of the building maintenance unit can be moved across the building front for maintenance purposes.

[0039] The building maintenance unit can preferably be combined with other automation possibilities, such as robotic facade washing or facade scanning. The synchronized movements of the building maintenance unit provided by this application can improve the efficiency and accuracy of these technologies, making them more automatable and effective in their tasks. By implementing the technical teaching of this application, building owners and maintenance companies can stay at the forefront of building maintenance technology, achieving higher levels of performance and cost savings.

[0040] It is understood that the above features and those to be explained below are usable not only in the combination indicated in each case, but also in other combinations or on their own, without leaving the scope of the present invention.

Brief description of the drawings

[0041] An embodiment example of the invention is shown in the drawings and will be explained in more detail in the following description. In the figures:

Fig. 1 shows a building with a building maintenance unit in a perspective view; and

Fig. 2 shows the building maintenance unit of Fig. 1 in a top view.

Detailed description

[0042] Fig. 1 shows a building 42 with a building maintenance 10 unit in a perspective view.

[0043] The building maintenance unit 10 comprises a base 12 having a first pivot point 14 and a first rigid arm 16 mounted on the base 12 and adapted to pivot around the first pivot point 14. The first arm 16 has an optional counter weight 18 arranged on a first section 20 of the first arm 16 and has a second pivot point 22 arranged on a second section 24 of the first arm 16. The first section 20 is leading from the first pivot point 14 to a first end 26 of the first arm 16 and the second section 24 is leading from the first pivot point 14 to a second end 28 of the first arm 16 opposite the first end 26.

[0044] The building maintenance unit 10 further comprises a second rigid arm 30 arranged on the second pivot point 22 with a third end 32 of the second arm 30. The second arm 30 is adapted to pivot around the second pivot point 22. The second arm 30 has a third pivot point 34 at a fourth end 36 of the second arm 30 opposite the third end 32.

[0045] The building maintenance unit 10 further comprises a rigid support element 38 arranged on the third pivot point 34 and adapted to pivot around the third pivot point 34. The support element 38 is further adapted to carry a cradle 40 for supporting workers and tools during maintenance of a building 42. The support element 38 is also adapted to lower and raise the cradle 40 relative to the support element 38. The support element 38 and the cradle 40 are linked such that a pivotal movement of the support element 38 causes a concurrent pivotal movement of the cradle 40,

[0046] The movement of the elements of the building maintenance unit 10 is affected by a plurality of drives 44, 46, 48. A first drive 44 is adapted to move the first arm 16 about the first pivot point 14, a second drive 46 is adapted to move the second arm 30 about the second pivot point 22, and a third drive 48 is adapted to move the support element 38 about the third pivot point 34

[0047] The control of the movement of the elements of the building maintenance unit 10 is affected a control unit 50 adapted to send a plurality of control signals. A first control signal is sent to the first drive 44, the first control signal adapted to move the first arm 16, a second control signal to the second drive 46, the second control signal adapted to move the second arm 30, and a third control signal to the third drive 48, the third control signal adapted to move the third arm 38.

[0048] The control unit 50 is also adapted, if the control unit 50 receives a movement command to move the cradle 40 from a present position to a new position, to send first, second and third control signals such that the cradle 40 at least substantially maintains a constant orientation during a movement to the new position until the new position is reached.

[0049] The building maintenance unit 10 is arranged on rails 52 that allow a movement along the y-axis of the base coordinate system 70 (see Fig. 2). In this embodiment, the base coordinate system 70 has its origin at the first pivot point 14 with its x-axis perpendicular to the y-axis of the base coordinate system 70 and a z-axis of base coordinate system 70 pointing downward along the vertical extension of the building 42.

[0050] The control unit 50 comprises a comprises a programmable logic controller 64 for calculating parameters for the movement of the cradle 40 and a plurality of inverters 66 for adjusting the movement of the plurality of drives 44, 46, 48. Further, the control unit 50 comprises at least one sensor 68 for monitoring one or more parameters from the group comprising position, speed and acceleration of the plurality of drives 44, 46, 48.

[0051] Fig. 2 shows the building maintenance unit of Fig. 1 in a top view. All reference numerals that have previously been introduced are maintained. All explanations made in the context of Fig. 1 also apply to Fig. 2 and are not repeated for a matter or conciseness.

[0052] Fig. 2 is provided to explain one of the preferred ways to calculate the required angular speeds of the drives. It is understood that the same approach for calculating the required angular speeds can be used for calculating the settings for required pivot angles.

[0053] In the calculations below, the following variables are used that are shown in Fig. 2: l_1 as the distance between the first pivot point and the second pivot point, l_2 as the distance between the second pivot point and the third pivot point, α as the angle of the first arm in the base coordinate system 70, β as the angle of the second arm in the base coordinate system 70, δ as the angle of the support element in the base coordinate system 70, x_{tot} as the distance between the first pivot point 14 and the third pivot point 34 along the x-axis of the reference coordinate system 72, and y_{tot} as the distance between the first pivot point 14 and the third pivot point 34 along the y-axis of the reference coordinate system 72.

[0054] Further, in the calculations below, the angular speed of the first arm is assumed to be constant, i.e. $\omega_\alpha(t) = \omega_\alpha = const.$. What will be determined in the following are the angular speeds of the second arm $\omega_\beta(t)$ and of the support element $\omega_\delta(t)$.

Movement along the x-axis of the relative coordinate system

[0055] Initially it is noted that a movement along the x-axis of the relative coordinate system can also be referred to as a perpendicular movement for explanation purposes. Such movement is considered perpendicular relative to a reference plane that is formed by the y-axis and the z-axis of the relative coordinate system. For explanation purposes, the short side of the cradle is considered to extend along the x-axis, and the long side of the cradle is considered to extend along the y-axis.

[0056] The angle of the cradle is determined by:

$$\gamma = \alpha + \beta + \delta \quad \text{(Equation 1)}$$

[0057] At the same time, this is the angle between the relative coordinate system and the base coordinate system. In other words, it is the angle by which the relative coordinate system is pivoted around the z-axis relative to the base coordinate system. The angle can be used to determine the angle of the first arm in the relative coordinate system:

$$\alpha_1 = -\gamma + \alpha \quad \text{(Equation 2)}$$

[0058] The distance between the first pivot point and the third pivot point in the y-direction can be determined as follows:

$$y_{tot} = l_1 \cdot \sin(\alpha_1) + l_2 \cdot \sin(\alpha_1 + \beta) \quad \text{(Equation 3)}$$

[0059] For a movement along the x-axis, i.e. perpendicular to the reference plane, y_{tot} needs to be kept constant. In other words, the relative coordinate system is moved along its own x-axis. Therefore, the angle of the second arm in the relative coordinate system can be determined as follows:

$$\beta_1 = -\alpha_1 + \sin^{-1}\left(\frac{y_{tot} - l_1 \cdot \sin(\alpha_1)}{l_2}\right) \quad \text{(Equation 4)}$$

[0060] The corresponding angle of the support element in the relative coordinate system is then:

$$\delta_1 = -\alpha_1 - \beta_1 \quad \text{(Equation 5)}$$

[0061] Since $\omega_\alpha \cdot t$ describes the change of the first angle over time, the changes of the second and third angles over time can be described as:

$$\beta_1(t) = -(\alpha_1 + \omega_\alpha \cdot t) + \sin^{-1}\left(\frac{y_{tot} - l_1 \cdot \sin(\alpha_1 + \omega_\alpha \cdot t)}{l_2}\right) \quad \text{(Equation 6)}$$

$$\delta_1(t) = -(\alpha_1 + \omega_\alpha \cdot t) - \beta_1(t) \quad \text{(Equation 7)}$$

[0062] In order to find the needed angular speeds, the corresponding derivatives are found as:

$$\omega_\beta(t) = \frac{d}{dt}\beta_1(t) = -\frac{\frac{l_1}{l_2} \cdot \omega_\alpha \cdot \cos(\alpha_1 + \omega_\alpha \cdot t)}{\sqrt{1 - \frac{(y_{tot} - l_1 \cdot \sin(\alpha_1 + \omega_\alpha \cdot t))^2}{{l_2}^2}}} - \omega_\alpha \quad \text{(Equation 8)}$$

$$\omega_\delta(t) = \frac{d}{dt}\delta_1(t) = \frac{\frac{l_1}{l_2} \cdot \omega_\alpha \cdot \cos(\alpha_1 + \omega_\alpha \cdot t)}{\sqrt{1 - \frac{(y_{tot} - l_1 \cdot \sin(\alpha_1 + \omega_\alpha \cdot t))^2}{{l_2}^2}}} \quad \text{(Equation 9)}$$

[0063] Therefore, $\omega_\alpha(t) = \omega_\alpha$, $\omega_\beta(t)$ and $\omega_\delta(t)$ can be calculated for a perpendicular movement of the cradle relative to the reference plane.

Movement along the y-axis of the relative coordinate system

[0064] A movement along the y-axis of the relative coordinate system can also be referred to as a parallel movement for explanation purposes. Such movement is considered parallel relative to the reference plane as explained above. The following considerations refer to a parallel movement of the cradle that is effected by pivoting around the first, second and third pivot points. It does not involve moving the cradle up or down, i.e. along the z-axis. This can be done independently by a hoisting mechanism which connects the cradle with the supporting element.

[0065] Again, the angle of the cradle is determined by:

$$\gamma = \alpha + \beta + \delta \quad \text{(Equation 1)}$$

[0066] This is, again, the angle between the relative coordinate system and the base coordinate system. Again, it can be used to determine the angle of the first arm in the relative coordinate system:

$$\alpha_1 = -\gamma + \alpha \quad \text{(Equation 2)}$$

[0067] The distance between the first pivot point and the third pivot point in the x-direction can be determined as follows:

$$x_{tot} = l_1 \cdot \cos(\alpha_1) + l_2 \cdot \cos(\alpha_1 + \beta) \quad \text{(Equation 10)}$$

[0068] For a movement along the y-axis of the relative coordinate system, i.e. parallel to the reference plane, x_{tot} needs to be kept constant. In other words, the relative coordinate system is moved along its own y-axis. Therefore, the angle of the second arm in the relative coordinate system can be determined as follows:

$$\beta_2 = -\alpha_1 - \cos^{-1}\left(\frac{x_{tot} - l_1 \cdot \cos(\alpha_1)}{l_2}\right) \quad \text{(Equation 11)}$$

[0069] The corresponding angle of the support element in the relative coordinate system is then:

$$\delta_2 = -\alpha_1 - \beta_2 \quad \text{(Equation 12)}$$

[0070] Since $\omega_\alpha \cdot t$ describes the change of the first angle over time, the changes of the second and third angles over time can be described as:

$$\beta_2(t) = -(\alpha_1 + \omega_\alpha \cdot t) - \cos^{-1}\left(\frac{x_{tot} - l_1 \cdot \cos(\alpha_1 + \omega_\alpha \cdot t)}{l_2}\right) \quad \text{(Equation 13)}$$

$$\delta_2(t) = -(\alpha_1 + \omega_\alpha \cdot t) - \beta_2(t) \quad \text{(Equation 14)}$$

[0071] In order to find the needed angular speeds, the corresponding derivatives are found as:

$$\omega_\beta(t) = \frac{d}{dt}\beta_2(t) = \frac{\frac{l_1}{l_2} \cdot \omega_\alpha \cdot \sin(\alpha_1 + \omega_\alpha \cdot t)}{\sqrt{1 - \frac{(x_{tot} - l_1 \cdot \cos(\alpha_1 + \omega_\alpha \cdot t))^2}{l_2{}^2}}} - \omega_\alpha \quad \text{(Equation 15)}$$

$$\omega_\delta(t) = \frac{d}{dt}\delta_2(t) = -\frac{\frac{l_1}{l_2} \cdot \omega_\alpha \cdot \sin(\alpha_1 + \omega_\alpha \cdot t)}{\sqrt{1 - \frac{(x_{tot} - l_1 \cdot \cos(\alpha_1 + \omega_\alpha \cdot t))^2}{l_2{}^2}}} \quad \text{(Equation 16)}$$

[0072] Therefore, $\omega_\alpha(t) = \omega_\alpha$, $\omega_\beta(t)$ and $\omega_\delta(t)$ can be calculated for a parallel movement of the cradle relative to the reference plane.

[0073] It is understood that the first control signal may be adapted to move the first arm 14 to a first pivot angle α, the second control signal may be adapted to move the second arm 30 to a second pivot angle β, and the third control signal may be adapted to move the third arm 38 to a third pivot angle δ. Alternatively, the first control signal may be adapted to move the first arm 14 at a first angular speed ω_α, the second control signal may be adapted to move the second arm 30 at a second angular speed ω_β, and the third control signal may be adapted to move the third arm 38 at a third angular speed ω_δ.

[0074] The present invention provides a building maintenance unit with automated cradle movement that is more accurate and efficient than existing systems. The system utilizes a combination of different drives and a control system that synchronizes their movement to achieve the desired movement of the cradle. The invention has numerous advantages over existing systems, including improved accuracy, efficiency, and resource optimization.

[0075] The preferred use of sensors such as absolute encoders, optical sensors, ultrasonic sensors, or any other suitable sensor for measuring the necessary parameters allows for the automatic synchronization of the different drives and the elimination of the need for the operator to control the movements separately. The building maintenance unit is preferably also capable of memorizing the last position on the facade and traveling there automatically on the next day to continue the work, further increasing its efficiency and ease of use.

Claims

1. A building maintenance unit (10) comprising

- a base (12) having a first pivot point (14),
- a first rigid arm (16) mounted on the base (12) and adapted to pivot around the first pivot point (14), the first arm (16) having a first section (20) of the first arm (16) and having a second pivot point (22) arranged on a second section (24) of the first arm (16), wherein the first section (20) is leading from the first pivot point (14) to a first end (26) of the first arm (16) and the second section (24) is leading from the first pivot point (14) to a second end (28) of the first arm (16) opposite the first end (26),
- a second rigid arm (30) arranged on the second pivot point (22) with a third end (32) of the second arm (30) and adapted to pivot around the second pivot point (22), the second arm (30) having a third pivot point (34) at a fourth end (36) of the second arm (30) opposite the third end (32),
- a rigid support element (38) arranged on the third pivot point (34) and adapted to pivot around the third pivot point (34), the support element (38) further adapted to carry a cradle (40) for supporting workers and tools during maintenance of a building (42) and adapted to lower and raise the cradle (40) relative to the support element (38), wherein the support element (38) and the cradle (40) are linked such that a pivotal movement of the support element (38) causes a concurrent pivotal movement of the cradle (40),
- a plurality of drives (44, 46, 48), wherein a first drive (44) is adapted to move the first arm (16) about the first pivot point (14), a second drive (46) is adapted to move the second arm (30) about the second pivot point (22), and a third drive (48) is adapted to move the support element (38) about the third pivot point (34), and
- a control unit (50) adapted to send a first control signal to the first drive (44), the first control signal adapted to move the first arm (16), a second control signal to the second drive (46), the second control signal adapted to move the second arm (30), and a third control signal to the third drive (48), the third control signal adapted to move the third arm (38),

wherein the control unit (50) is further adapted, if the control unit (50) receives a movement command to move the cradle (40) from a present position to a new position, to send first, second and third control signals such that the cradle (40) at least substantially maintains a constant orientation during a movement to the new position until the new position is reached.

2. The building maintenance unit (10) of claim 1, wherein the first control signal is adapted to move the first arm (16) to a first pivot angle (α), the second control signal is adapted to move the second arm (30) to a second pivot angle (β), and the third control signal is adapted to move the third arm (38) to a third pivot angle (δ).

3. The building maintenance unit (10) of claim 1, wherein the first control signal is adapted to move the first arm (16) at a first angular speed (ω_α), the second control signal is adapted to move the second arm (30) at a second angular speed (ω_β), and the third control signal is adapted to move the third arm (38) at a third angular speed (ω_δ).

4. The building maintenance unit (10) of any preceding claim, wherein the control unit (50) is adapted to send the first, second and third control signals repeatedly.

5. The building maintenance unit (10) of any preceding claim, wherein the first arm (16) is adapted to pivot in a first plane and the second arm (30) is adapted to pivot in a second plane, wherein the first plane is at least substantially parallel to the second plane.

6. The building maintenance unit (10) of any preceding claim, wherein the second arm (30) is adapted to pivot in a second plane and the support element (38) is adapted to pivot in a third plane, wherein the second plane is at least substantially parallel to the third plane.

7. The building maintenance unit (10) of any preceding claim, wherein the support element (38) is adapted to pivot in a third plane, wherein the support element (38) is further adapted to lower and raise the cradle (40) relative to the support element (38) along an axis that is at least substantially orthogonal to the third plane.

8. The building maintenance unit (10) of any preceding claim, wherein the control unit (50) comprises a programmable logic controller (64) for calculating parameters for the movement of the cradle (40) and/or a plurality of inverters (66) for adjusting the movement of the plurality of drives (44, 46, 48).

9. The building maintenance unit (10) of any preceding claim, wherein the control unit (50) further comprises at least one sensor (68) for monitoring one or more parameters from the group comprising position, speed and acceleration of the plurality of drives (44, 46, 48).

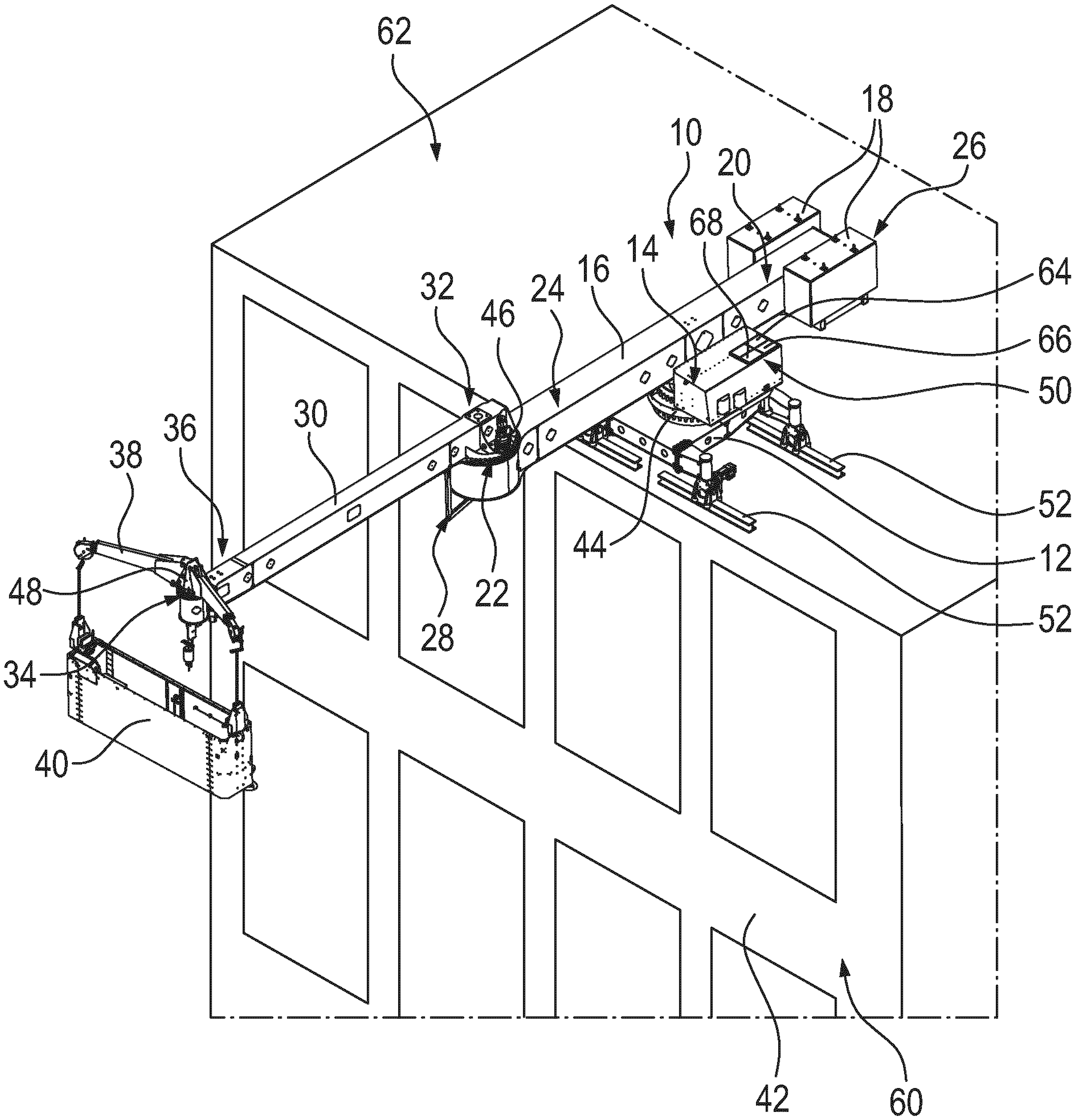
10. The building maintenance unit (10) of claim 9, wherein the at least one sensor (68) comprises one or more of absolute encoders, optical sensors and/or ultrasonic sensors.

11. The building maintenance unit (10) of any preceding claim, wherein a control of the building maintenance unit (10) is performed by a joystick, a button, or a human-machine interface communicatively linked to the control unit (50).

12. The building maintenance unit (10) of any preceding claim, wherein the control unit (50) optimizes the use of power and other resources by adjusting the movement of the cradle.

13. The building maintenance unit (10) of any preceding claim, wherein the base (12) is arranged on rails (52) that are adapted to be installed on a building (42) and that are further adapted to allow for a movement of the base (12) along the top of a building front (60) of the building (42) on which the building maintenance unit (10) is installed.

14. A building (42) having a building front (60) and a building maintenance unit (10) of any preceding claim arranged on a roof section (62) of the building (42) such that the cradle (40) of the building maintenance unit (10) can be moved across the building front (60) for maintenance purposes.


62
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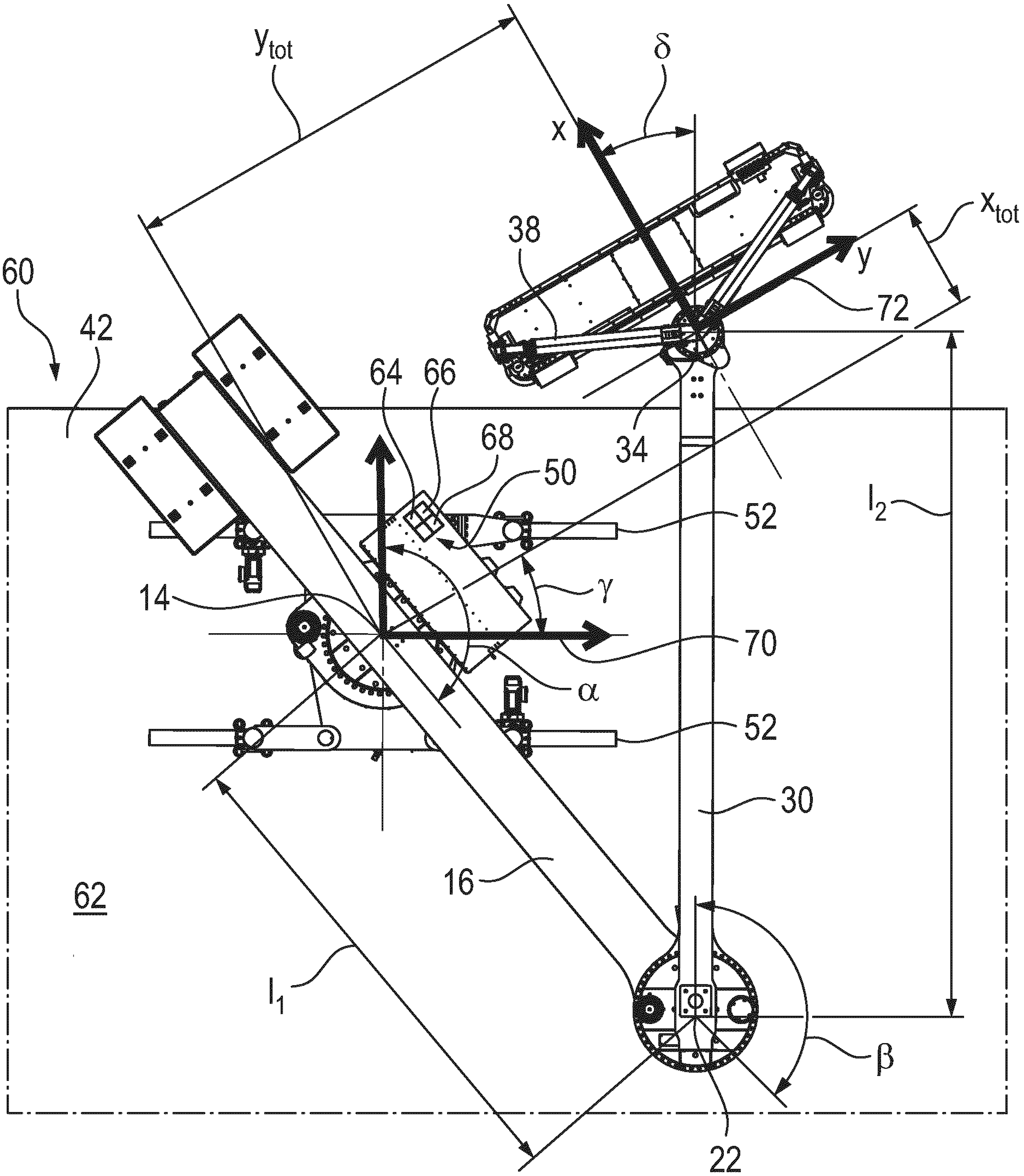
60

Fig. 1



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y
x_{tot}
72
60
42
64
66
68
50
34
52
l_2
14
γ
70
α
52
30
62
16
l_1
β
22

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 4805

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	3 November 2023	Tryfonas, N

CATEGORY OF CITED DOCUMENTS

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03-11-2023

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