

Description

WALL SURFACE WORK DEVICE AND METHOD

Technical Field

[0001]

The present disclosure relates to an apparatus and a method for performing work, such as inspection and painting, on a wall surface.

Background Art

[0002]

Conventionally, when performing some work (painting, attachment of a machine, inspection, and the like) on a wall surface of a building, other structure, a natural object, or the like, generally, a scaffold is built along the wall surface to allow a person to go back and forth, and the person climbs on the scaffold to perform the work. However, it takes a considerable amount of effort and cost to build a scaffold that is strong enough for a person to safely perform work, and the manual work itself also takes effort and cost.

[0003]

Therefore, it has been proposed and put into practical use to substitute such work with a small flying apparatus (for example, refer to the following Patent Literatures 1 and 2).

Citation List

Patent Literature

[0004]

Patent Literature 1: Japanese Patent Laid-Open No. 2020-203564

Patent Literature 2: Japanese Utility Model Registration No. 3225084

Patent Literature 3: Japanese Patent Laid-Open No. 2017-169395

Summary of Invention

Technical Problem

[0005]

Generally, such a flying apparatus called a drone is small, has a high flight stability, is easy to turn and easy to operate, and is utilized in various fields. On the other hand, there is naturally a limit to the weight that can be mounted, and for example, when performing some work on a wall surface or the like, although simple inspection work, such as obtaining an image of a target, can be performed without much difficulty, it is not suitable for work that requires carrying of an object with a certain amount of weight. Therefore, similar technologies have not yet been introduced to simplify work in situations such as painting of a surface wall and attachment of devices to a wall surface.

[0006]

Accordingly, in the present disclosure, a description will be given of a wall surface work apparatus that can simply and suitably perform work on a wall surface.

Solution to Problem

[0007]

The present disclosure relates to a wall surface work apparatus, including a travelling body configured to be able to travel on a wall surface, and a work device that is mounted on the travelling body, and performs work on the wall surface, wherein the travelling body is configured to be supported from left and right sides by and to be manipulated in position by support manipulation cords that are fed from positions of ascending/descending bodies in ascending/descending support apparatuses that include support columns installed on left and right sides of the travelling body and the ascending/descending bodies that ascend/descend along the support columns.

[0008]

Additionally, the present disclosure relates to a wall surface work apparatus, including a travelling body configured to be able to travel on a wall surface, and a work device that is mounted on the travelling body, and performs work on the wall surface, wherein the travelling body is configured to be supported by and manipulated in

position by support manipulation cords that are fed from at least left and right sides of the travelling body.

[0009]

In the above-described wall surface work apparatus, the travelling body can be configured to include propellers that generate a pressing force to the wall surface.

[0010]

In the above-described wall surface work apparatus, the propellers can be variable-pitch propellers.

[0011]

In the above-described wall surface work apparatus, an auxiliary cord can be connected to the travelling body so as to apply tension to the travelling body from a direction different from the support manipulation cords.

[0012]

The above-described wall surface work apparatus can also include a weight suspended from the travelling body.

[0013]

In the above-described wall surface work apparatus, the travelling body can be configured to include an attaching unit that attaches onto the wall surface.

[0014]

The above-described wall surface work apparatus can further include the ascending/descending support apparatuses that include the support columns installed on the left and right sides of the travelling body, and the

ascending/descending bodies that ascend/descend along the support columns, and the support manipulation cords that are fed from the positions of the ascending/descending bodies, support the travelling body from the left and right sides, and manipulate a position of the travelling body.

[0015]

The above-described wall surface work apparatus can be configured to identify the position of the travelling body on the wall surface based on heights of the ascending/descending bodies, and feeding lengths of the support manipulation cords.

[0016]

In the above-described wall surface work apparatus, the support manipulation cords can be configured to be fed from feeding apparatuses of the support manipulation cords loaded into the ascending/descending bodies.

[0017]

In the above-described wall surface work apparatus, the travelling body includes an attaching unit that attaches onto the wall surface, an attachment-related device used for operation of the attaching unit is loaded into the ascending/descending body, and the attaching unit and the attachment-related device can be connected by a communication cord.

[0018]

In the above-described wall surface work apparatus,

a work-related device used in relation to work by the work device is loaded into the ascending/descending body, and the work device and the work-related device can be connected by the communication cord.

[0019]

Additionally, the present disclosure relates to a wall surface work method, wherein a travelling body configured to be able to travel on a wall surface, and a work device that is mounted on the travelling body, and performs work on the wall surface are used, and the travelling body is supported by and a position of the travelling body is manipulated by support manipulation cords that are fed from at least left and right sides of the travelling body.

Effect of Invention

[0020]

According to the wall surface work apparatus and method, it is possible to achieve an excellent effect that work on a wall surface can be simply and suitably performed.

Brief Description of Drawings

[0021]

FIG. 1 is a schematic view illustrating an example (a first embodiment) of the general constitution of a wall surface work apparatus in the present disclosure;

FIG. 2 is a front view illustrating an example of the mode of a travelling body constituting the wall surface work apparatus;

FIG. 3 is a side view of the travelling body in FIG. 2;

FIG. 4 is a conceptual diagram explaining calculation of the position of the travelling body constituting the wall surface work apparatus;

FIG. 5 is a schematic view illustrating another example (a second embodiment) of the general constitution of a wall surface work apparatus in the present disclosure;

FIG. 6 is a schematic view illustrating still another example (a third embodiment) of the general constitution of a wall surface work apparatus in the present disclosure;

FIG. 7 is a schematic view illustrating still another example (a fourth embodiment) of the general constitution of a wall surface work apparatus in the present disclosure;

FIG. 8 is a schematic view illustrating still another example (a fifth embodiment) of the general constitution of a wall surface work apparatus in the present disclosure.

Description of Embodiment

[0022]

Embodiments of the present disclosure will be described below with reference to the accompanying drawings.

[0023]

FIG. 1 to FIG. 3 illustrate an example (a first embodiment) of the mode of a wall surface work apparatus in the present disclosure. A wall surface work apparatus 1 of the first embodiment includes a travelling body 2 and a pair of ascending/descending support apparatuses 3, and is configured to support the travelling body 2 by support manipulation cords 4 extending from the left and right ascending/descending support apparatuses 3, and manipulate the position of the travelling body 2, while causing the travelling body 2 to travel along a wall surface W, which is a work target.

[0024]

Note that, in the present description, it is assumed that a "wall surface" refers to various kinds of surfaces oriented along a vertical plane, such as an outer surface of a building or a wall as a partition, a fence dividing an outdoor region, or an inner wall of a machine or facility such as a power plant furnace, or further, a cliff surface of a natural structure. "A surface oriented along a vertical plane" does not refer to only a flat surface that is precisely perpendicular to the gravity direction, but may be a curved surface, or may be inclined to some extent. A surface-like structure that

can be intuitively recognized by a person as a wall surface or a surface similar to that may correspond to the "wall surface" in the present description.

[0025]

The travelling body 2 includes wheels 2b as travelling units at each of the four corners of a body 2a that is constructed by combining rod-shaped structural members into a square shape, and is configured to be able to travel on the wall surface W with the wheels 2b contacting the wall surface W as illustrated in FIG. 3. Each of the wheels 2b is configured as, for example, a ball caster attached to a back side of the travelling body 2 (note that, here, regarding the travelling body 2, it is assumed that the side facing the wall surface W is called the "back side", and the opposite side is called a "front side"), and the travelling body 2 is configured to be able to freely travel in any directions along the wall surface with rotation of the wheels 2b. Note that "travelling" as used in the present description shall not only refer to travelling on wheels, but also means general moving operations along a wall surface. That is, in implementation of the wall surface work apparatus, when causing the travelling body to travel along a wall surface, the mechanism for travelling is not limited to the wheels as illustrated here. Additionally, as the specific configurations of the body 2a and the travelling units (wheels) 2b, as long as work can be performed

without difficulty as describe later, various modes may be employed in addition to the configurations described here.

[0026]

Additionally, propellers 2c for generating a pressing force to press the entire travelling body 2 toward the wall surface W are provided on the front side of the travelling body 2. The propellers 2c are configured to blow air from the travelling body 2 to the front side with rotation, and press the entire travelling body 2 to the back side with the reaction, thereby holding the travelling body 2 onto the wall surface W.

[0027]

Here, from a viewpoint of improving the responsiveness with respect to the manipulation of the travelling body 2, it is particularly suitable to employ so-called variable-pitch propellers as the propellers 2c. A variable-pitch propeller is a propeller configured to be able to freely vary the pitch, and can change the size and direction of thrust while maintaining the rotation direction and the rotation speed constant. That is, when the propellers 2c are variable-pitch propellers, the propellers 2c can variously change the size of the pressing force onto the wall surface W, can also make the pressing force zero while keeping rotation in the same direction, and further, can generate a negative pressing force (a force in a direction away from the wall surface

W).

[0028]

The attachment positions of the two support manipulation cords 4 in the travelling body 2 are the upper right and the upper left of the body 2a in the case of the first embodiment. For example, although it is also possible to connect the two support manipulation cords 4 to one point of an upper portion of the body 2a to suspend and support the travelling body 2, in that case, along with the operation of the travelling body 2 along the wall surface W, movement may be generated that causes the travelling body 2 to sway in left and right directions with respect to the wall surface W below a supporting point by the support manipulation cords 4. Therefore, as illustrated in FIG. 1, when the support manipulation cords 4 are connected to two different points, respectively, and the travelling body 2 is suspended by the tension from the two points, the movement of the travelling body 2 is restrained by the two points, and accordingly, occurrence of swaying in the left and right directions can be suppressed.

[0029]

Further, in the case of the first embodiment, the travelling body 2 is provided with an attaching unit 5 for attaching onto the wall surface W. As the attaching unit 5, for example, the same apparatus as an apparatus that is sold under the name of "vacuum gripper", "vacuum

suction gripper", "vacuum suction pad", "suction lifter" or the like, and an apparatus utilizing the principles common to these can be used. That is, the attaching unit 5 is configured as a pneumatic suction apparatus that draws in the air between the attaching unit 5 and the wall surfaces W to generate negative pressure, thereby holding the entire travelling body 2 to which the attaching unit 5 is attached onto the wall surface W. Alternatively, when assuming a structure (for example, a furnace wall of a thermal power plant or the like) made from a magnetic body such as iron as the wall surface W, which is a work target, the attaching unit 5 may be configured as an electromagnetic attraction apparatus. That is, the attaching unit 5 includes an electromagnet, and when the electromagnet is energized, attaches onto the wall surface W, which is the magnetic body, is made by an electromagnetic force. Further, apparatuses using various kinds of mechanisms and principles, such as a model that attaches onto the wall surface W by an electrostatic force, can be employed as the attaching unit 5, as long as the apparatuses can appropriately attach onto the wall surface W.

[0030]

Note that, when the attaching unit 5 is a pneumatic suction apparatus, a pump and a tube for drawing in the air are separately required, and when the attaching unit 5 is an electromagnetic or electrostatic attraction

apparatus, although it depends on the attractive force required, a power supply apparatus and a power supply cable for supplying electric power from the outside are separately required. In the wall surface work apparatus 1 in the first embodiment, a device such as the pump and the power supply apparatus that are used for the operation of the attaching unit 5 can be loaded into basket 3b as an attachment-related device 5a. Additionally, the attaching unit 5 mounted on the travelling body 2 and the attachment-related device 5a loaded into the basket 3b can be connected with a tube or a power supply cable as a communication cord 6. The communication cord 6 is a cable, a hose, a tube, or a bundle of these for connecting the device mounted on the travelling body 2 to the device loaded into the basket 3b.

[0031]

In this manner, in the first embodiment, the travelling body 2 is configured to be held onto the wall surface W by both the pressing force by the propellers 2c and the attractive force by the attaching unit 5. Note that, in implementation of a wall surface work apparatus, only either the propellers or the attaching unit may be provided to the travelling body, depending on conditions, such as the mounting weight of devices for the travelling body.

[0032]

Additionally, work device 7 for performing work on the wall surface W is mounted on the travelling body 2. The specific configuration of the work device 7 varies depending on the content of work: for example, when painting the wall surface W, the work device 7 is a nozzle or the like for spraying paint; when inspecting the wall surface W, the work device 7 is a camera or other measurement device for obtaining an image of the wall surface W; and when attaching a certain component, apparatus, or the like to the wall surface W, the work device 7 is a tool or the like. Depending on the configuration or content of work of the work device 7, a power supply cable for supplying electric power, a communication cable for exchanging data obtained by the work device 7, a manipulation signal to be input to the work device 7, and the like, a supply tube for supplying paint, or the like is connected to the work device 7 as the communication cord 6.

[0033]

The ascending/descending support apparatuses 3 include support columns 3a that are installed on the left and right sides of the travelling body 2 along the wall surface W, and baskets 3b as ascending/descending bodies that ascend/descend along the support columns 3a. Winding machines or the like, which are not illustrated, are installed at suitable positions of the support columns 3a, and the baskets 3b can vertically

ascend/descend along the support columns 3a by actuation of the winding machines or the like. Note that, although the basket 3b is exemplified here as the ascending/descending body, the configuration of the ascending/descending body is not limited to this. For example, the ascending/descending body may be configured as a table that ascends/descends along the support column 3a. Additionally, the mechanism for ascending/descending the ascending/descending body is not limited to the winding machine, and, for example, a self-elevating ascending/descending apparatus may be employed.

[0034]

Further, for example, an apparatus similar to various kinds of apparatuses that are sold as apparatuses for scaffold work can be used as the ascending/descending support apparatus 3. For example, the applicant sells apparatuses, such as "Power Mast" (product name) and "Power Lift" (product name) for moving a scaffold for wall surface work up and down along a support column, and "Power Climber" (product name) for moving a basket for unloading up and down along a support column for a scaffold for wall surface work, and these apparatuses can be converted as they are, or partially modified, into the ascending/descending support apparatus in the wall surface work apparatus.

[0035]

The baskets 3b are loaded with the winding machines

8 as feeding apparatuses of the support manipulation cords 4 for manipulating the travelling body 2 via the support manipulation cords 4. The support manipulation cords 4 are wire ropes for supporting the travelling body 2, and the winding machines 8 are apparatuses that feed and wind the support manipulation cords 4. A pair of support manipulation cords 4 that are fed from the positions of the baskets 3b on the left and right sides are connected to the travelling body 2, so as to be able to support the travelling body 2 from the left and right sides and to manipulate the position of the travelling body 2. The baskets 3b are also loaded with motors (not illustrated) as power sources for the winding machines 8. Note that, although the positions for installing the winding machines 8 and the motors, which are not illustrated, may not be at the baskets 3b, in order to manipulate the travelling body 2 by the support manipulation cords 4 while moving the baskets 3b up and down as will be described later, it is simple to load the winding machines 8 into the baskets 3b.

[0036]

Additionally, the basket 3b is loaded with devices (work-related device 7a) that are used in relation to the work by the work device 7 mounted on the travelling body 2. For example, a power supply apparatus of the work device 7, a communication cable in a case where the work device 7 is manipulated by wire, a paint tank in a case

where the work device 7 is a nozzle for painting, and the like correspond to the work-related device 7a. The work-related device 7a loaded into the basket 3b and the work device 7 are connected by the communication cord 6.

[0037]

Additionally, the wall surface work apparatus 1 is provided with height sensors 13 for measuring the heights of the baskets 3b provided to the ascending/descending support apparatuses 3. The height sensors 13 are, for example, laser distance sensors. In the case of the first embodiment, the height sensors 13 are provided at the height of the ground at the positions where the left and right ascending/descending support apparatuses 3 in FIG. 1 are installed, and can identify the heights of the baskets 3b by perpendicularly emitting irradiation light toward the baskets 3b located above, and detecting the reflected light from the baskets 3b. Note that the height sensors 13 may be attached to the baskets 3b side, instead of the height of the ground.

[0038]

Additionally, at least one of the baskets 3b (in the case of the first embodiment, the basket 3b on the left in the figure) is provided with a distance sensor 9 for detecting the distance to the other basket 3b. The distance sensor 9 is, for example, a laser distance sensor, and can identify the distance between the baskets 3b attached to the left and right ascending/descending

support apparatuses 3 by horizontally emitting irradiation light from one basket 3b toward the other basket 3b, and detecting the reflected light from the other basket 3b. Note that, as long as the height and distance can be appropriately identified, meters (for example, an ultrasonic distance sensor and the like) having the other mechanisms may be suitably used as the height sensors 13 and the distance sensor 9.

[0039]

Each of the aforementioned devices constituting the wall surface work apparatus 1 is controlled by a control unit 10. The control unit 10 is a control apparatus that monitors and controls the operation of each of the devices constituting the wall surface work apparatus 1, and inputs control signals to the motors (not illustrated) of the winding machines for moving the baskets 3b of the ascending/descending support apparatuses 3 up and down, the motors (not illustrated) for the winding machines 8 for feeding and winding the support manipulation cords 4, the propellers 2c and the attaching unit 5 that are mounted on the travelling body 2, and the devices such as the work device 7, the attachment-related device 5a, and the work-related device 7a, and controls turning on/off and operations of these. Additionally, the measured values of the distance sensor 9 and the height sensors 13 are input to the control unit 10 as data signals.

[0040]

Additionally, an operation unit 11 is connected to the control unit 10, an operator of the wall surface work apparatus 1 inputs a manipulation signal to the control unit 10 through manipulation of this operation unit 11, and the control unit 10 is configured to control each device in accordance with this manipulation signal. Additionally, a display unit 12, which is a liquid crystal display or the like, may be connected to the control unit 10 according to the needs, and the operating status (the heights and ascending/descending speeds of the baskets 3b, the position of the travelling body 2, the actuation statuses of the attaching unit 5 and the work device 7, the feeding statuses of the support manipulation cords 4 from the winding machines 8, and the like) of each device may be displayed. Note that, as the operation unit 11, for example, a product commercially available as a controller for a gaming machine or the like can also be used, and a touch-panel display of a smart phone, a tablet, or the like can also be used. When the operation unit 11 is configured as a touch-panel display, the operation unit 11 can also function as the display unit 12.

[0041]

Next, the actuation of the aforementioned first embodiment will be described.

[0042]

In use of the wall surface work apparatus 1, first, the support columns 3a are installed on the left and right of the wall surface W, which is a work target. The baskets 3b attached to the support columns 3a are loaded with the respective winding machines 8, and the pair of support manipulation cords 4 that are fed from the winding machines 8 are attached to the travelling body 2. While the required work device 7 is mounted on the travelling body 2, the basket 3b is loaded with the work-related device 7a and the attachment-related device 5a, and the attaching unit 5 and the attachment-related device 5a are connected by the communication cord 6, and the work device 7 and the work-related device 7a are connected by the communication cord 6.

[0043]

In this state, the winding machines, which are not illustrated, of the ascending/descending support apparatuses 3, are operated to raise the left and right baskets 3b along the support columns 3a. The travelling body 2 is suspended by the support manipulation cords 4 that are fed from the left and right winding machines 8, and is raised with the baskets 3b.

[0044]

When the travelling body 2 is suspended to an appropriate height, feeding and winding of the support manipulation cords 4 are performed by the winding machines 8 loaded into the left and right baskets 3b,

thereby manipulating the position of the travelling body 2. The height and position in the up/down/left/right directions of the travelling body 2 with respect to the baskets 3b are determined by the feeding amounts of the support manipulation cords 4 from the left and right winding machines 8. That is, the smaller the feeding amounts of the support manipulation cords 4, the closer the height at which the travelling body 2 is supported to the baskets 3b, and the larger the feeding amounts of the support manipulation cords 4, the lower the travelling body 2 is suspended with respect to the baskets 3b. Additionally, in a state where the winding machines 8 are supported by the tension of the left and right support manipulation cords 4, when the feeding amount of the support manipulation cord 4 from the left winding machine 8 is larger than the feeding amount from the right winding machine 8, the travelling body 2 is located on the right side between the left and right support columns 3a and 3a, and when the feeding amount from the left winding machine 8 is smaller than the feeding amount from the right winding machine 8, the travelling body 2 is located on the left side between the left and right support columns 3a and 3a.

[0045]

When performing such manipulation, the position of the travelling body 2 on the wall surface W can be simply identified by, for example, the calculation as follows.

[0046]

It is assumed that d is the distance between the winding machines 8 provided to the baskets 3b of the left and right ascending/descending support apparatuses 3 (refer to FIG. 4). It is assumed that the distances from the left and right winding machines 8 to the travelling body 2 are l_1 and l_2 , respectively. When it is assumed that the heights of the left and right winding machines 8 are h_1 and h_2 , respectively, the following equations hold for the coordinates (x, y) of the travelling body 2 on the wall surface W between the left and right ascending/descending support apparatuses 3.

$$x^2 + (h_1 - y)^2 = l_1^2 \dots\dots (1)$$

$$(d - x)^2 + (h_2 - y)^2 = l_2^2 \dots\dots (2)$$

[0047]

The distances l_1 and l_2 can be identified through the feeding lengths of the support manipulation cords 4 from the respective winding machines 8, and the feeding lengths of the support manipulation cords 4 can be identified by encoders (not illustrated) provided to the respective winding machines 8. The heights h_1 and h_2 can be identified by the measured values of the height sensors 13 (refer to FIG. 1). Therefore, the coordinates (x, y) of the travelling body 2 can be identified by solving the aforementioned equations (1) and (2) as simultaneous equations. Note that, in FIG. 4, although the travelling body 2 and the winding machines 8 are

illustrated as dots to simplify the calculation, since the actual travelling body 2 and winding machines 8 have sizes, these may be suitably considered in an actual operation.

[0048]

Additionally, the distance d between the winding machines 8 is constant when the respective support columns 3a of the ascending/descending support apparatuses 3 are considered to be rigid bodies that are always perpendicular. However, in fact, by suspending the travelling body 2, the left and right support columns 3a may be bent by the tension of the support manipulation cords 4, which may vary the distance d . When it is desired to consider this variation in the distance d , such as when it is necessary to identify the precise position of the travelling body 2, the correct distance d between the baskets 3b may be measured by the distance sensor 9 (refer to FIG. 1) attached to the basket 3b, and this may be taken into account at the time of calculation of the coordinates of the travelling body 2.

Additionally, on that occasion, the positions and the like of the baskets 3b with respect to the wall surface W and installation surfaces of the support columns 3a may be measured, and these may be taken into consideration. When measuring the positions of the baskets 3b with respect to the wall surface W and the installation surfaces of the support columns 3a, the functions of the

distance sensor 9 and the height sensors 13 may be utilized, or sensors that are not illustrated may be separately provided.

[0049]

Note that, in the above calculation procedure, for representing the coordinates of the travelling body 2, the position of the origin is set to the root of the support column 3a on the left side in the figure.

However, the position of the origin is not limited to this, and may be suitably set.

[0050]

Here, when manipulating the travelling body 2, there may be a difference between the height of the left and right winding machines 8 and the height of the travelling body 2 to some extent. However, when the difference is too large, the horizontal component of the tension of the support manipulation cords 4 that support the travelling body 2 from the left and right sides becomes small, and there is a possibility that manipulation of the left-and-right position of the travelling body 2 by the support manipulation cords 4 becomes difficult. Additionally, since there is also a limitation on the lengths of the communication cords 6, it is not preferable that the difference between the height of the left and right winding machines 8 and the height of the travelling body 2 becomes too large. On the other hand, when the difference between the height of the winding machines 8

and the height of the travelling body 2 is too small, the tension of the support manipulation cords 4 required for supporting the weight of the travelling body 2 becomes great, which may cause significant deflection of the support columns 3a. Therefore, in manipulation of the travelling body 2, care should be taken to ensure that the difference between the height of the baskets 3b and the height of the travelling body 2 is within a reasonable range.

[0051]

While holding the travelling body 2 itself on the wall surface W by the operations of the propellers 2c and the attaching unit 5, the position of the travelling body 2 in the up/down/left/right directions with respect to the wall surface W is manipulated by the support manipulation cords 4 as described above, such that the travelling body 2 travels along the wall surface W. Then, various kinds of work, such as inspection and painting, is performed on the wall surface W by the work device 7.

[0052]

A series of manipulation, such as adjustment of the heights of the baskets 3b, adjustment of the position of the travelling body 2 by the support manipulation cords 4, and various kinds of work by the work device 7, can be performed by inputting the manipulation signal from the operation unit 11. Additionally, during work, the

operating statuses of various kinds of devices are displayed on the display unit 12, the travelling body 2 and the ascending/descending support apparatuses 3 are visually inspected, and visual information displayed on the display unit 12 also allows identification of a detailed operating status. Note that the operation unit 11 may handle only a part of the aforementioned various kinds of manipulation. For example, the ascending/descending of the baskets 3b may be performed through other controllers provided to the ascending/descending support apparatuses 3.

[0053]

During manipulation of the wall surface work apparatus 1, when it is desired to significantly move the travelling body 2 on a wall surface, the pressing force by the propellers 2c and the attractive force by the attaching unit 5 may hinder the movement. In such a case, when the actuation of the propellers 2c and the attaching unit 5 is turned off (or the output is reduced), and the heights of the baskets 3b and the feeding lengths of the support manipulation cords 4 are manipulated in a state where the pressing force and the attractive force are cut (reduced), the travelling body 2 can be moved more smoothly and quickly. Here, when the propellers 2c are configured as variable-pitch propellers, the pressing force can be reduced or made to zero while maintaining rotation, without turning off the

actuation of the propellers 2c. Therefore, the manipulation of the propellers 2c and the travelling body 2 can be performed with a better responsiveness.

[0054]

Additionally, an obstacle that hinders travelling of the travelling body 2, for example, a projecting object such as a column, may exist on the wall surface W. On that occasion, when the propellers 2c are variable-pitch propellers, it is also possible to generate a negative pressing force to separate the travelling body 2 from the wall surface W, and to quickly move the travelling body 2 by avoiding the obstacle without bypassing the obstacle.

[0055]

When various kinds of work is performed on the wall surface W by using the wall surface work apparatus 1 as described above, it is unnecessary to build a scaffold along the wall surface W to allow a person to go back and forth, and the support columns 3a of the ascending/descending support apparatuses 3 may be installed on the wall surface W. Therefore, as compared with a case of performing work by human power, the effort and time required for installation of the scaffold can be significantly reduced. Additionally, also when performing actual work, such as inspection and painting, on the wall surface W, it is unnecessary for a person to undergo effort to move up/down/left/right by using a lifting platform or a scaffold, and the amount of work

can be reduced to shorten the construction period. In addition, since actual work on the wall surface W is directly performed not by a person but by the travelling body 2, when supporting the travelling body 2 on the wall surface W, compared with a case where a person performs actual work, the required support strength is lower. Accordingly, not only the effort and time related to the work for building a scaffold can be saved as described above, but the cost for installing the support columns 3a themselves can also be further reduced.

[0056]

Note that, in the wall surface work apparatus 1 as in the first embodiment, it is difficult for the travelling body 2 to perform work in the vicinity of the support columns 3a. Therefore, for the wall surface W in the vicinity of the support columns 3a, for example, a person may climb into the basket 3b to perform work, or work may be performed by changing the installation positions of the support columns 3a.

[0057]

Additionally, the wall surface work apparatus 1 in the first embodiment can also perform work that needs to support an object with a certain amount of weight with respect to the wall surface W. For example, in the technology using the flying apparatus as described in the aforementioned Patent Literatures 1 and 2, the weight of usable work devices depends on the carrying capacity of

the flying apparatus. Therefore, only simple work, such as obtaining an image of the wall surface W, can be practically performed, and the technology was not fit for work that uses a heavy device. In the case of the wall surface work apparatus 1 in the first embodiment, most of the weight of the travelling body 2, the attaching unit 5 mounted on the travelling body 2, and the work device 7 is not supported by the flying capability or the holding power onto the wall surface W of the travelling body 2, but by the tension of the support manipulation cords 4 attached to the travelling body 2. Therefore, a greater weight can be supported. Further, when the attachment-related device 5a used for the operation of the attaching unit 5, and the work-related device 7a used for the work by the work device 7 are suitably loaded into the basket 3b, and these are connected by the communication cord 6, the attaching unit 5 and the work device 7 can be actuated, while sharing the weight required for the operation of the attaching unit 5 and the work by the work device 7 between the travelling body 2 and the basket 3b, and reducing the load on the travelling body 2. In this manner, it is possible to reasonably perform extensive work that uses a device with a certain amount of weight.

[0058]

FIG. 5 illustrates another mode (a second embodiment) of the wall surface work apparatus in the

present disclosure. Although the basic configuration of the wall surface work apparatus 1 in the second embodiment is common to that in the aforementioned first embodiment illustrated in FIG. 1, in the case of the second embodiment, in addition to the support manipulation cords 4 that support and manipulate the travelling body 2, two auxiliary cords 14 are connected to the travelling body 2. The auxiliary cords 14 are fed from feeding apparatuses 15 provided at lower right and lower left positions in the wall surface work apparatus 1 (separately from the winding machines 8 that feed the support manipulation cords 4), and tips are connected to a lower right and a lower left of the body 2a of the travelling body 2, respectively. Note that, although the positions of the feeding apparatuses 15 that feed the auxiliary cords 14 are in the vicinity of bases of the left and right support columns 3a in FIG. 5, the feeding apparatuses 15 may be suitably installed at other positions.

[0059]

The role of the auxiliary cords 14 in the wall surface work apparatus 1 in the second embodiment is applying tension to the travelling body 2 from directions different from the support manipulation cords 4, thereby suppressing the movement of the travelling body 2 to stabilize the position. When supporting the travelling body 2 only by the support manipulation cords 4 that

extend from the left and right sides as in the aforementioned first embodiment (refer to FIG. 1), there is a possibility that a pendulum-like swaying movement in front and back directions with respect to the wall surface W occurs in the travelling body 2, and this may interfere with work. Therefore, as in the second embodiment, by connecting the auxiliary cords 14 to the travelling body 2 in addition to the support manipulation cords 4, and applying tension by the auxiliary cords 14 from directions different from the support manipulation cords 4, unnecessary movement of the travelling body 2 can be suppressed.

[0060]

As the feeding apparatus 15 that feeds the auxiliary cord 14, for example, a tension apparatus such as a linear body feeding apparatus described in the aforementioned Patent Literature 3 can be used. Such a tension apparatus includes a reel that feeds and winds a cord, and a motor that controls the tension to the cord in accordance with the change in the tension applied to the cord, and is configured to always apply tension to the cord, while automatically performing feeding and winding of the cord. With such a mechanism, while allowing movement of an apparatus such as a drone connected to the cord, when the apparatus performs sudden movement, this can be suppressed. Further, a suitable apparatus can be used as the feeding apparatus 15, as

long as the apparatus can apply an appropriate tension to the travelling body 2 moving on a wall surface via the auxiliary cord 14, and can suppress the movement of the travelling body 2 while allowing travelling of the travelling body 2.

[0061]

As the feeding apparatus 15, for example, a general winding machine may be used, and it is also possible to configure all of the feeding apparatuses 8 that feed the support manipulation cords 4, and the feeding apparatuses 15 that feed the auxiliary cords 14 as winding machines. However, at least for the feeding apparatuses that feed the support manipulation cords 4 (in the case of the second embodiment, the feeding apparatuses 8 located in the upper right and the upper left in FIG. 5), it is necessary to use apparatuses such as winding machines that can support the weight of the travelling body 2 by the support manipulation cords 4, and can freely manipulate the positions of the support manipulation cords 4 via feeding and winding of the support manipulation cords 4.

[0062]

Further, when the auxiliary cords 14 are attached to the travelling body 2 in this manner, it is also possible to tilt the travelling body 2 to some extent by manipulating the feeding lengths of the support manipulation cords 4. For example, considering a case of

performing the movement of slightly feeding the support manipulation cord 4 from the winding machine 8 located on the left side in the figure, or the movement of slightly winding the support manipulation cord 4 located on the right side, or both of these, when the auxiliary cords 14 are not attached as in the aforementioned first embodiment (refer to FIG. 1), the travelling body 2 will be slightly moved to the right side in the figure (on that occasion, depending on the content of manipulation, the travelling body 2 will also be slightly moved up and down). However, in the case of the second embodiment illustrated in FIG. 5, since the movement of a lower portion of the travelling body 2 is limited by the auxiliary cords 14 that are fed from the feeding apparatuses 15, when the manipulation as described above is performed in the winding machines 8, the travelling body 2 will be tilted clockwise toward the wall surface W, without changing the position. It is conceivable that such manipulation is effective, depending on the content of work performed by using the travelling body 2.

[0063]

FIG. 6 illustrates still another mode (a third embodiment) of the wall surface work apparatus in the present disclosure. In the case of the third embodiment, although the basic configuration is the same as that in the aforementioned second embodiment (refer to FIG. 5), the attachment positions of the support manipulation

cords 4 and the auxiliary cords 14 on the travelling body 2 are different. A pair of support manipulation cords 4 fed from the left and right winding machines 8 are attached to one location of an upper portion of the body 2a of the travelling body 2, and a pair of auxiliary cords 14 fed from the left and right feeding apparatuses 15 are attached to one location of the lower portion of the body 2a of the travelling body 2. In this way, the attachment positions of the support manipulation cords 4 and the auxiliary cords 14 on the travelling body 2 are not limited to the examples illustrated in FIG. 1 and FIG. 5, and the support manipulation cords 4 and the auxiliary cords 14 can be attached to suitable positions.

[0064]

FIG. 7 illustrates yet another mode (a fourth embodiment) of the wall surface work apparatus in the present disclosure. Although in the aforementioned second and third embodiments (refer to FIG. 5 and FIG. 6), the modes have been described in which the travelling body 2 is supported by a total of four cords, i.e., the two auxiliary cords 14 are added to the two support manipulation cords 4, in the case of the wall surface work apparatus 1 in the fourth embodiment, the travelling body 2 is supported by a total of three cords, i.e., one auxiliary cord 14 is added to the two support manipulation cords 4. The auxiliary cord 14 is fed from the feeding apparatus 15 provided below, and a tip is

connected to the lower portion of the body 2a of the travelling body 2. In this manner, the number of the auxiliary cords 14 is not limited to two as in the aforementioned second embodiment, and may be one as in the fourth embodiment, or may be three or more.

[0065]

Additionally, in the case of the fourth embodiment, the feeding apparatus 15 that feeds the auxiliary cord 14 is configured to be able to travel left and right along a rail, as indicated by a solid line in FIG. 7. With such a configuration, by adjusting the feeding position of the auxiliary cord 14 in accordance with the position of the travelling body 2, it is possible to perform manipulation such that the direction of the tension applied by the auxiliary cord 14 to the travelling body 2 is always from substantially directly below. For example, as indicated by broken lines in FIG. 7, the auxiliary cord 14 may be fed from the feeding apparatus 15 fixed to an appropriate position. However, in that case, a possibility is conceivable that depending on the position of the travelling body 2, the tension applied to the travelling body 2 is biased to either left or right, and manipulation by the support manipulation cord 4 becomes somewhat difficult. As in the example illustrated here by the solid line, when the feeding position of the auxiliary cord 4 and the direction of the auxiliary cord 4 with respect to the travelling body 2 can be adjusted

in accordance with the position of the travelling body 2, it is possible to obtain a good operativity for manipulation of the travelling body 2 via the support manipulation cord 4.

[0066]

Further, for the travelling body 2, as illustrated in FIG. 5 to FIG. 7, when the travelling body 2 is supported by two or more points by the support manipulation cord 4 and the auxiliary cord 14, the travelling body 2 can be suitably supported and its position can be manipulated, and further, when tension is applied to three or more directions that are different from each other, swaying of the travelling body 2 can be suitably suppressed.

[0067]

FIG. 8 illustrates still another mode (a fifth embodiment) of the wall surface work apparatus in the present disclosure. In the fifth embodiment, instead of applying tension to the travelling body 2 by the auxiliary cords 14 and the feeding apparatuses 15 as illustrated in the aforementioned second to fourth embodiments (refer to FIG. 5 to FIG. 7), a weight 16 is suspended downward from the travelling body 2, and the weight 16 pulls the travelling body 2 downward by its own weight, thereby suppressing unnecessary movement of the travelling body 2.

[0068]

Note that, in attachment of the weight 16 to the travelling body 2, for example, the following manners are conceivable. However, the manner of attaching the weight to the travelling body is not limited to these examples.

[0069]

1) A movable connection mechanism, such as a bearing, is provided at a suitable position of the travelling body 2 (for example, on a frame of the lower portion of the body 2a), a rod-shaped component is attached so as to extend downward from the connection mechanism, and the weight 16 is connected to a tip of the rod-shaped component. The weight 16 moves on the circumference whose radius is the length of the rod-shaped component, and whose center is the connection mechanism.

[0070]

2) The rod-shaped component is fixed so as to extend downward from the body 2a of the travelling body 2, and the weight 16 is connected to the tip of the rod-shaped component. The weight 16 is fixed to a constant position with respect to the travelling body 2.

[0071]

3) A cord is provided so as to extend downward from the body 2a of the travelling body 2, and the weight 16 is suspend at the tip of the cord. The weight 16 moves to rotate on the circumference of a bottom surface of a cone whose vertex is at a base end of the cord.

[0072]

Further, the auxiliary cords 14 and the feeding apparatuses 15 as illustrated in the aforementioned second to fourth embodiments (refer to FIG. 5 to FIG. 7), and the weight 16 may be used together. Alternatively, it is also possible to suitably provide a mechanism, such as a pulley, in the middle of the support manipulation cords 4 and the auxiliary cords 14, and to adjust the direction of the tension applied to the travelling body 2. For example, a tension apparatus as a feeding apparatus may be installed obliquely downward of the travelling body 2, a pulley or a suitable component similar to the pulley may be provided under the travelling body 2, and the auxiliary cord fed from the tension apparatus may be wound once around the pulley (or the similar component), and thereafter the tip of the auxiliary cord may be attached to the lower portion of the travelling body 2.

[0073]

As described above, the wall surface work apparatus 1 in each of the aforementioned embodiments includes the travelling body 2 configured to be able to travel on the wall surface W, and the work device 7 that is mounted on the travelling body 2, and performs work on the wall surface W, and the travelling body 2 is configured to be supported from the left and right sides by and to be manipulated in position by the support manipulation cords

4 that are fed from the positions of the ascending/descending bodies 3b in the ascending/descending support apparatuses 3 that include the support columns 3a installed on the left and right sides of the travelling body 2, and the ascending/descending bodies (baskets) 3b that ascend/descend along the support columns 3a.

[0074]

Additionally, the wall surface work apparatus 1 in each of the aforementioned embodiments includes the travelling body 2 configured to be able to travel on the wall surface W, and the work device 7 that is mounted on the travelling body 2, and performs work on the wall surface W, and the travelling body 2 is configured to be supported by and manipulated in position by the support manipulation cords 4 that are fed from at least the left and right sides of the travelling body 2.

[0075]

Additionally, in the wall surface working method in each of the aforementioned embodiments, the travelling body 2 configured to be able to travel on the wall surface W, and the work device 7 that is mounted on the travelling body 2, and performs work on the wall surface W are used, and the travelling body 2 is supported by and the position of the travelling body 2 is manipulated by the support manipulation cords 4 that are fed from at least the left and right sides of the travelling body 2.

[0076]

In this manner, when performing work on the wall surface W, it is unnecessary to build a scaffold along the wall surface W to allow a person to go back and forth, and effort and time can be significantly saved. Additionally, also when performing actual work, such as inspection and painting, on the wall surface W, the amount of work can be reduced.

[0077]

Additionally, in the wall surface work apparatus 1 in each of the embodiments, the travelling body 2 includes the propellers 2c that generates a pressing force to the wall surface W. In this manner, the travelling body 2 can be held onto the wall surface W by the pressing force.

[0078]

Additionally, in the wall surface work apparatus 1 in each of the embodiments, the propellers 2c can be variable-pitch propellers. In this manner, the adjustment of the pressing force by the propellers 2c can be quickly performed, and the manipulation of the propellers 2c and the travelling body 2 can be performed with a good responsiveness. In addition, it is possible to generate a negative pressing force by the propellers 2c to separate the travelling body 2 from the wall surface W, and to quickly move the travelling body 2.

[0079]

Additionally, in the wall surface work apparatus 1 in some of the embodiments, the auxiliary cord(s) 14 are connected to the travelling body 2 so as to apply tension to the travelling body 2 from direction(s) different from the support manipulation cords 4. In this manner, by applying tension by the auxiliary cord(s) 14 from direction(s) different from the support manipulation cords 4, unnecessary movement of the travelling body 2 can be suppressed.

[0080]

Additionally, the wall surface work apparatus 1 in some of the embodiments includes the weight 16 suspended from the travelling body 2. In this manner, the weight 16 can suppress unnecessary movement of the travelling body 2 by its own weight.

[0081]

Additionally, in the wall surface work apparatus 1 in each of the embodiments, the travelling body 2 includes the attaching unit 5 that attaches onto the wall surface W. In this manner, the travelling body 2 can be held onto the wall surface W by the attractive force.

[0082]

Additionally, the wall surface work apparatus 1 in each of the embodiments further includes the ascending/descending support apparatuses 3 that includes the support column 3a installed on the left and right sides of the travelling body 2, and the

ascending/descending bodies 3b that ascend/descend along the support columns 3a, and the support manipulation cords 4 that are fed from the positions of the ascending/descending bodies 3b, support the travelling body 2 from the left and right sides, and manipulate the position of the travelling body 2. In this manner, by supporting most of the weight of the travelling body 2 and the devices mounted on the travelling body 2 by the tension of the support manipulation cords 4, a heavy weight can be supported, and extensive work can be reasonably performed.

[0083]

Additionally, the wall surface work apparatus 1 in each of the embodiments is configured to be able to identify the position of the travelling body 2 on the wall surface W based on the heights of the ascending/descending bodies 3b, and the feeding lengths of the support manipulation cords 4. In this manner, in manipulation of the travelling body 2, the position of the travelling body 2 can be simply identified.

[0084]

Additionally, in the wall surface work apparatus 1 in each of the embodiments, the support manipulation cords 4 are fed from the feeding apparatuses (winding machines) 8 of the support manipulation cords 4 loaded into the ascending/descending bodies 3b. In this manner, the position of the travelling body 2 can be manipulated

by feeding and winding of the support manipulation cords 4 by the winding machines 8.

[0085]

Additionally, in the wall surface work apparatus 1 in each of the embodiments, the travelling body 2 includes the attaching unit 5 that attaches onto the wall surface W, the attachment-related device 5a used for the operation of the attaching unit 5 is loaded into the ascending/descending body 3b, and the attaching unit 5 and the attachment-related device 5a are connected by the communication cord 6. In this manner, the weight required for the operation of the attaching unit 5 can be shared between the travelling body 2 and the ascending/descending body 3b, and the load on the travelling body 2 can be reduced.

[0086]

Additionally, in the wall surface work apparatus 1 in each of the embodiments, the work-related device 7a used in relation to the work by the work device 7 is loaded into the ascending/descending body 3b, and the work device 7 and the work-related device 7a are connected by the communication cord 6. In this manner, the weight required for the work by the work device 7 can be shared between the travelling body 2 and the ascending/descending body 3b, and the load on the travelling body 2 can be reduced.

[0087]

Accordingly, according to each of the aforementioned embodiments, work on a wall surface can be simply and suitably performed.

[0088]

It should be noted that the wall surface work apparatus and method described in the present disclosure are not limited to the above-described embodiments, and it goes without saying that various changes can be made without departing from the scope of the present invention.

Reference Signs List

[0089]

- 1 wall surface work apparatus
- 2 travelling body
 - 2a body
 - 2b wheel
 - 2c propeller
- 3 ascending/descending support apparatus
 - 3a support column
 - 3b ascending/descending body (basket)
- 4 support manipulation cord
- 5 attaching unit
 - 5a attachment-related device
- 6 communication cord
- 7 work device
 - 7a work-related device

- 8 feeding apparatus (winding machine)
- 9 distance sensor
- 10 control unit
- 11 operation unit
- 12 display unit
- 13 height sensor
- 14 auxiliary code
- 15 feeding apparatus (tension apparatus)
- 16 weight
- W wall surface

Claims

1. A wall surface work apparatus, comprising:
 - a travelling body configured to be able to travel on a wall surface; and
 - a work device that is mounted on the travelling body, and performs work on the wall surface,wherein the travelling body is configured to be supported from left and right sides by and to be manipulated in position by support manipulation cords that are fed from positions of ascending/descending bodies in ascending/descending support apparatuses that include support columns installed on left and right sides of the travelling body and the ascending/descending bodies that ascend/descend along the support columns.
2. A wall surface work apparatus, comprising:
 - a travelling body configured to be able to travel on a wall surface; and
 - a work device that is mounted on the travelling body, and performs work on the wall surface,wherein the travelling body is configured to be supported by and manipulated in position by support manipulation cords that are fed from at least left and right sides of the travelling body.
3. The wall surface work apparatus according to claim 1

or 2, wherein the travelling body includes propellers that generate a pressing force to the wall surface.

4. The wall surface work apparatus according to claim 3, wherein the propellers are variable-pitch propellers.

5. The wall surface work apparatus according to any one of claims 1 to 4, wherein an auxiliary cord is connected to the travelling body so as to apply tension to the travelling body from a direction different from the support manipulation cords.

6. The wall surface work apparatus according to any one of claims 1 to 5, comprising a weight suspended from the travelling body.

7. The wall surface work apparatus according to any one of claims 1 to 6, wherein the travelling body includes an attaching unit that attaches onto the wall surface.

8. The wall surface work apparatus according to any one of claims 1 to 6, further comprising:

ascending/descending support apparatuses that include support columns installed on left and right sides of the travelling body, and ascending/descending bodies that ascend/descend along the support columns; and
support manipulation cords that are fed from

positions of the ascending/descending bodies, support the travelling body from left and right sides, and manipulate a position of the travelling body.

9. The wall surface work apparatus according to claim 8, wherein the wall surface work apparatus is configured such that the position of the travelling body on the wall surface can be identified based on heights of the ascending/descending bodies, and feeding lengths of the support manipulation cords.

10. The wall surface work apparatus according to claim 8 or 9, wherein the support manipulation cords are fed from feeding apparatuses of the support manipulation cords loaded into the ascending/descending bodies.

11. The wall surface work apparatus according to any one of claims 8 to 10,

wherein the travelling body includes an attaching unit that attaches onto the wall surface,

an attachment-related device used for operation of the attaching unit is loaded into the ascending/descending body, and

the attaching unit and the attachment-related device are connected by a communication cord.

12. The wall surface work apparatus according to any one

of claims 8 to 11, wherein a work-related device used in relation to work by the work device is loaded into the ascending/descending body, and the work device and the work-related device are connected by a communication cord.

13. A wall surface work method,

wherein a travelling body configured to be able to travel on a wall surface, and

a work device that is mounted on the travelling body, and performs work on the wall surface are used, and

the travelling body is supported by and a position of the travelling body is manipulated by support manipulation cords that are fed from at least left and right sides of the travelling body.