AUTOMATED BUILDING FACADE CLEANING APPARATUS

TECHNICAL FIELD

The present invention relates to an automated cleaning apparatus ideally suited for cleaning the external facade of a building structure or the like, such as a high-rise multi-storey building. The apparatus has a user-defined cleaning sequence which caters for a wide variety of cleaning circumstances.

BACKGROUND ART

One of the consequences of our increasingly crowded urban society, and the rapid development of architectural and building technology, has been the development of high-rise multi-storey buildings, often comprising scores or even more than one hundred floors.

This development has brought with it the problem of cleaning the facades of such buildings, including windows and walls, a problem which has become a central issue of the usage and maintenance of buildings of this kind. Platforms that can move vertically adjacent to the building facade are commonly installed on high-rise buildings, but the control procedures are complex and the cleaning job is time-consuming and labour-costly. Often such cleaning is inadequate or inefficient due to the limited range of manual cleaning.

In addition, the safety of the operating personnel used in prior cleaning platforms has been of major concern. Mistakes made by personnel when operating the platform, or an accidental breakdown of its structure, may result in accidents which can be fatal. Further, wind turbulence in the air between high-rise buildings is also potentially hazardous.

Numerous devices have been proposed for washing the windows and walls of high-rise buildings by means of unmanned units which traverse the exterior surfaces of the buildings. Some units are self-propelled; others are raised and lowered by means of cables connected to the tops of the building. Such units have included means for delivering cleaning liquid such as water or detergent solutions, and have included means for scrubbing the window wall such as brushes and/or sponges and have included means for retarding the degrees of cleaning liquid in the form of squeegee blades. Such devices are shown in U.S. Patent Nos.

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5,465,446 (Chang, Nov. 14, 1995); 4,025,984 (Hoener, Jr., May 31, 1977); 5,086,533 (Kitahara, Feb. 11, 1992); 4,257,138 (Clements et al, March 24, 1981); 3,895,406 (Fannon, Jr., July 22, 1975); 4,136,419 (Hetman et al, Jan. 30, 1979); 4,198,724 (Fisher et al; April 22, 1980); 3,999,242 (Maruyama et al, Dec. 28, 1976). To date such devices have experienced only limited commercial acceptance.

Automated systems are usually customized to the configuration of the window profile of a particular building and cannot be used on windows or facades having extended ledges, or on buildings having varying window profiles at different levels. This includes any other demanding architecture such as concave and/or convex features, and deeply recessed and/or protruding features.

The above-mentioned prior art, all have in one form or another a device to squeeze out the water and cleaning solution, that is there is contact between the cleaning device such as a brush or wiper and the window or wall.

DISCLOSURE OF THE INVENTION

It is an object of the present invention to provide an automated cleaning apparatus for cleaning the external facade of a building which goes at least some way towards overcoming or at least minimising the prior art problems or limitations outlined above and/or for providing a clear alternative choice for the intended users.

It is another object of this invention to provide an automated cleaning apparatus for cleaning the external facade of a building which is universally adaptable for use with various forms of building structures.

It is a further object of this invention to provide an automated cleaning apparatus for cleaning the external facade of a building which has a user-defined cleaning sequence which caters to a wide configuration of cleaning circumstances.

It is yet another object of the present invention to provide an automated cleaning apparatus for cleaning the external facade of a building which includes a remotely-controlled computer programmable mobile unit which is adapted to traverse the contour or profile of the building facade and to clean the facade by means of high-pressure water sprays.

These and other objects of the invention will become more apparent from the following descriptions and the drawings.

SUMMARY OF THE INVENTION

According to one aspect of the present invention there is provided an automated cleaning apparatus for cleaning the external facade of a building, said apparatus comprising:-

- a gantry unit adapted to be mounted on and to traverse a running track adjacent to the outer perimeter of an upper roof or top wall of the building, said gantry unit including a support frame which extends outwardly beyond the perimeter of the building;

- a mobile gondola unit suspended from the support frame of the gantry unit adjacent to the facade of the building by adjustable cable means, said gondola unit being adapted for vertical movement relative to the position of the gantry unit;

- a cleaning unit mounted on the gondola, including a high-pressure water pump operatively connected to one or more spray nozzles directed towards the building facade and adapted to oscillate from side to side circumscribing a horizontal arc; and

- control means operatively connected to said gantry unit and to said gondola unit to control all aspects of operation and position of both said units.

Ideally, the spray nozzles are provided in corresponding pairs, spaced apart equidistant from the centre of the gondola unit, with each nozzle of each pair adapted to circumscribe a horizontal arc in the same plane as its counterpart but moving in opposite directions. In other words the nozzles are in anti-phase, and the movement of one such nozzle substantially mirrors the movement of its counterpart nozzle to counteract any tendency for displacement of the gondola unit as a result of the side components of the reaction forces from each nozzle.

The apparatus comprises a movable gantry or roof unit and a mobile gondola unit. The roof unit controls the ascending and descending of the gondola unit. The gondola unit has a set of sweeping jets of pressurized water preferably from two nozzles. The jets of water sweep

across the building facade to dislodge stains and dust. The apparatus can be programmed to clean any particular section of walls and/or windows on the building in whichever manner the user deems most suitable.

Water jets can be programmed to shut off while transversing over areas of the facade which do not need to be cleaned to cut down on unnecessary wastage of water.

The roof unit is free to move around the periphery of the rooftop of the building so as to clean the entire building's windows or facade without dismantling. As the mobile unit moves, the water jets will be projected onto the area that is to be cleaned, as circumscribed by the sweeping loci. The ascending and descending sequence and speed of the mobile unit, sweeping loci and speed of the nozzles and the water pressure provided by the pump are controlled by a computer program. This permits the user to adjust the distance of the mobile unit from the face of the windows by changing the length of the tension cables. The clearance of the roof unit from the window face is in turn determined by the by the building's architecture. The water pressure will adjust accordingly so the water jets can reach the face of the window with the same cleaning efficiency. The sweeping loci can be programmed to suit different window profiles.

The suspension cables linked to the mobile unit are suspended from the arms extended from the roof unit. The arms are capable of pivoting about the front base plate of the roof unit to allow adjustment of clearance of the mobile unit from the face of the building. A tension cable that runs from near the tip of the arms to the roof unit base keeps the arms in place. The suspension cable, which is slung over the pulley at the end tip of each arm, is spooled, powered by a 3-phase A.C induction motor. This controls the ascending and descending of the mobile unit. To prevent bias spooling, the suspension cable ideally passes through a cable guide unit. The suspension cable is laid between a set of guideposts and in turn the guideposts are mounted onto a guide block. The guide block is propelled in alternating directions by a ballscrew, which is in turn powered by a reversible single-phase A.C induction motor. Perspex core cladded by a stainless steel metal detector serves as guideposts. This allows the suspension cable to spool evenly. An induction motor powered set of wheels on the underside of the roof unit allows the entire apparatus to reel around the periphery of the building roof on rails. The building will then be able to have its facade, including all its windows, cleaned by having only one apparatus on its roof.

BRIEF DESCRIPTION OF THE ACCOMPANYING DRAWINGS

The invention will now be described by way of example only with reference to the accompanying drawings wherein:-

FIG. 1 is a perspective view of the movable gantry of roof unit, rail mounted on a track on the roof of a building adjacent to the outer perimeter thereof; and

FIG. 2 is a perspective view of the mobile gondola unit suspended from the support frame of the movable gantry or roof unit of Figure 1 adjacent to the facade of the building. A cleaning unit comprising a high-pressure water pump connected to spray nozzles arranged on either side of the mobile unit is adapted to spray pressurised water onto the adjacent portions of the building facade.

DESCRIPTION OF A PREFERRED EMBODIMENT; BEST MODE OF CARRYING OUT THE INVENTION

Referring to Figs. 1 and 2, the apparatus catering to different configuration of building facade or window profile according to this embodiment of the invention is comprised of a roof unit (Fig. 1) and a mobile unit (Fig. 2). The roof unit is capable of raising and lowering the mobile unit.

Referring to Fig. 1, the movable gantry or roof unit 1 comprises a carriage with wheels 2 mounted on the rails 3 of a running track adjacent to the outer periphery or perimeter 4 of the roof 3A of a building.

The motorized wheels 2 fitted under the roof unit 1 allow it to transverse along the rails 3 that run the periphery of the rooftop 3A. Two arms 5 extend from the roof unit and pivot about its base, as at 6. The arms 5 are held in its angle of tilt by the tension cable 7 which runs from near the tip of the arm 8 to the front base plate 9 of the roof unit. The suspension cable 10 that held the mobile unit 16 (Fig. 2) are spooled by a motorized cable spool 11 powered by a 3 phase induction motor 12 mounted on the front base plate. The suspension cable 10 thus extends from the cable spool 11, via the cable guide 13, slung around the pulley 14 at the tip of the arm and to the mobile unit 16. The cable guide comprises of a set

of guideposts which the suspension cable passes in between. The set is in turn mounted on a guide block via a guide post mount. The guide post block is constrained to move in a side along manner by a ballscrew and a dummy shaft (not shown). The ballscrew is in turn powered by a single phase AC induction motor 15 which turns the ballscrew in an alternating clockwise and counterclockwise manner. This in turn moves the guide block from side to side. Thus as the suspension cable 10 reels in between the guideposts to the cable spool 11, it will be laced evenly over the spine length of the cable spool, preventing premature failure of the suspension cable due to twisting under minimum coiling radius. To prevent the roof unit 1 from tipping over the edge 4 of the roof top due to the weight of the gondola 16, a counter-balance weight 30 is attached to the inner side of the roof unit.

Referring to Fig. 2, the mobile gondola unit 16 consists of an aluminium frame 17 with a set of sliding rods 18, 19 mounted lengthwise on each side of the frame. Upon each set of siding rods, a nozzle assembly 20, 21 is mounted such that it is free to slide along the sliding rods. The nozzle assembly comprises of a set of nozzle base plate 22 and nozzle base plate fixtures. Upon the nozzle plate, a set of geared turntable 23 and driving gear 24 are mounted and meshed. The geared turntable has the nozzle 25 mounted on it. A stepper motor (not shown) drives the driving gear. Thus controlling the stepper motor through a computer program can circumscribe the motion of the nozzle 25, 26. According to the invention, the two nozzles are set to circumscribe a horizontal arc, sweeping from side to side. A high pressure water pump 27 sited in-between the two sets of sliding rods will provide two jets of pressurized water 28 via the nozzles for cleaning. The pressure of the water jets can be changed according to the clearance of the roof unit from the facade or window face 31. The motion of the corresponding pairs of nozzles will substantially mirror one another (in opposing motion). Hence by having the nozzles 25 and 26 either turning towards or away from each other at any one time, any instability due to side components of the reaction forces from the nozzle will be eliminated. By reducing the pressure as the nozzles turn towards the window, the forward component of the reaction forces can also be kept constant. As prescribing to the concerned window profile, the distance between the nozzles 25, 26 can be adjusted by sliding the nozzle assembly 20, 21 along the sliding rods 18, 19. To suit the circumstances, the angle of the arc, which the nozzle is required to circumscribe, can also be changed together with the sweeping frequency by changing the computer program controlling the stepper motors.

Thus by changing the speed of the wheels 2, the start stop sequence, the speed of the cable spool 11, the length of the tension cable 7, the pressure of the water jets 28, the distance between the nozzles 25 and 26, the sweeping arclength and frequency, a wide configuration of building architecture and window profile can be serviced or cleaned.

A computer program synchronizing all the motors on board as well as the high-pressure water pump allows the user to custom its own cleaning sequence.

A computer integrates and controls all the functions of the gondola and the cleaning unit. A graphical user interface serves as an operator interface for:

- Starting and stopping the system and various components.
- Changing operational settings before and during operations, examples include speed of gondola and cleaning unit speed of reciprocation.
- Offline programming the motion of the gondola for a cleaning sequence for a building, including simulation of the cleaning motions.
- Real-time control and override of settings, motions, cleaning actions during actual operations.
- Monitoring of actual operations via remote camera that feeds into the user interface.

Operation of the automated cleaning apparatus is ideally via a computer that controls the gondola and cleaning unit with a graphical user interface for operator monitoring and control. This allows for an operator in a remote control room operating the system via the graphical user interface, aided by a video monitoring system that feeds into the operator control room.

The spacing between the two nozzles 25 and 26 can be adjusted by sliding units 20 and 21 along the slider rods 18 and 19. The oscillating movements of the nozzles is synchronized such that they are always 180 degrees out of phase, or at any one time, they are either swerving towards or away from each other. In this way, destabilizing side component of the reaction forces from the water jets, which can cause unit 16 to swing from side to side, can be eliminated. By reducing the water pressure gradually as the nozzles 25 and 26 are

turning towards the window, forward component of the reaction forces from the water jets, which can periodically push unit 16 away from the window if it is not constant, can also be maintained at the same magnitude. The high pressure water pump 27 can either be sited in situ between the sets of slider rods 18 and 19 and fed by an independent water hose 29 or it can be sited remotely and provides a pressurized hose to the nozzles 25 and 26.

In operation, roof unit 1 will be driven on the rails 3 to the desired position on the rooftop 3A. The suspension cable 10 will reel off the cable spool 11, sling over the pulley 14 at the tip of the aluminium arm 5 and extend downwards to the mobile gondola unit 16. Upon reaching the desired level, the high-pressure water pump 27 will operate to supply pressurized water to the nozzles 25, 26. The stepper motors will start rotating and hence set the nozzles into swerving motion. The water jets 28 will project onto the area that is to be cleaned. The high velocity jets will impact the area and dislodge any dust and stain. With the combination of horizontal movement provided by roof unit 1, vertical movement by the suspension cables 10 and the freedom of water jet projection distance provided by the high pressure water pump 27, mobile unit 16 can reach out to clean any spot on the building exterior face 31. The cleaning apparatus may optionally include a waste water redirection kit for proper disposal or recycling of waste water.

Although an exemplary embodiment of the present invention has been shown and described, it will be apparent to those having ordinary skill in the art that a number of changes, modifications or alterations to the invention described herein may be made, none of which depart from the spirit of the present invention. All such changes, modifications and alterations should therefore be seen as being within the scope of the present invention. For example, although the invention has been described in relation to an automated cleaning apparatus it will be appreciated that the apparatus could be used to clean exterior building walls prior to painting, or that the invention can be improvised as a high rise building external fire fighting unit.

It should be appreciated that the present invention provides a substantial advance in automated cleaning apparatus, providing all of the herein described advantages without incurring any relative disadvantages.



CLAIMS

1. An automated cleaning apparatus for cleaning the external facade of a building, said apparatus comprising:-

   - a gantry unit adapted to be mounted on and to traverse a running track adjacent to the outer perimeter of an upper roof or top wall of the building, said gantry unit including a support frame which extends outwardly beyond the outer perimeter of the building;

   - a mobile gondola unit suspended from the support frame of the gantry unit adjacent to the facade of the building by adjustable cable means, said gondola unit being adapted for vertical movement relative to the position of the gantry unit;

   - a cleaning unit mounted on the gondola unit, including a high-pressure water pump operatively connected to one or more spray nozzles directed towards the building facade and adapted to oscillate from side to side circumscribing a horizontal arc; and

   - remote control means operatively connected to said gantry unit and to said gondola unit to control all aspects of operation and position of both said units.

2. An automated cleaning apparatus as claimed in Claim 1, wherein the control means to control the operation of the apparatus include a computer program.

3. An automated cleaning apparatus as claimed in Claim 1 or Claim 2, wherein operation of said apparatus is via a computer which controls the operation via a graphical user interface for operator monitoring and control of said apparatus.

4. An automated cleaning apparatus as claimed in any one of the preceding claims wherein the operation of the apparatus is via an operator in a remote control room via the graphical user interface, aided via video monitoring means which is linked to the operator control room.

5. An automated cleaning apparatus as claimed in Claim 4, wherein the computer program control means has a user-defined cleaning sequence which is capable of operating in a variety of cleaning circumstances.

6. An automated cleaning apparatus as claimed in Claim 1, wherein the spray nozzles are provided in corresponding pairs, spaced apart equidistant from the centre of the gondola unit, with each nozzle of each pair adapted to circumscribe a horizontal arc in the same plane of its counterpart but moving in opposite directions.

7. An automated cleaning apparatus as claimed in Claim 6, wherein the nozzles of each pair circumscribe a horizontal arc in anti-phase.

8. An automated cleaning apparatus as claimed in Claim 5, which can be programmed to clean any particular section of the facade of the building.

9. An automated cleaning apparatus as claimed in Claim 5 or Claim 8, wherein the spray nozzles can be programmed to turn on or shut off while traversing over predetermined sections of the facade.

10. An automated cleaning apparatus as claimed in any one of the preceding claims, wherein the sweeping loci of the oscillating spray nozzles can be programmed to suit different facade or building window profiles.

11. An automated cleaning apparatus as claimed in any one of the preceding claims, wherein the support frame on the gantry unit includes means to allow adjustment of clearance of the mobile gondola unit from the facade of the building.

12. An automated cleaning apparatus as claimed in any one of the preceding claims, wherein the adjustable cable means is coiled or spooled onto storage spools on the gantry unit, and wherein cable guide means are provided to facilitate orderly spooling onto the storage spools.

13. An automated cleaning apparatus as claimed in any one of the preceding claims, wherein the cleaning unit includes a nozzle assembly for the spray nozzles having a geared turntable and driving gear to control the oscillation of each nozzle, and wherein each nozzle is operatively connected to a high pressure water pump.

14. An automated cleaning apparatus as claimed in Claim 13, wherein each nozzle assembly is slidably mounted on a horizontal, laterally-extending running track mounted on the mobile gondola unit.

15. An automated cleaning apparatus as claimed in any one of the preceding claims, substantially as hereinbefore described and illustrated with reference to the drawings.