

[54] **WINDOW WALL WASHING DEVICE FOR HIGH-RISE BUILDINGS**

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[22] Filed: **Feb. 28, 1972**

[21] Appl. No.: **229,846**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 130,616, April 2, 1971, abandoned.

[52] U.S. Cl..... **15/302, 15/346, 15/380**

[51] Int. Cl..... **A47I 5/38**

[58] Field of Search..... **15/302, 345, 346, 15/380**

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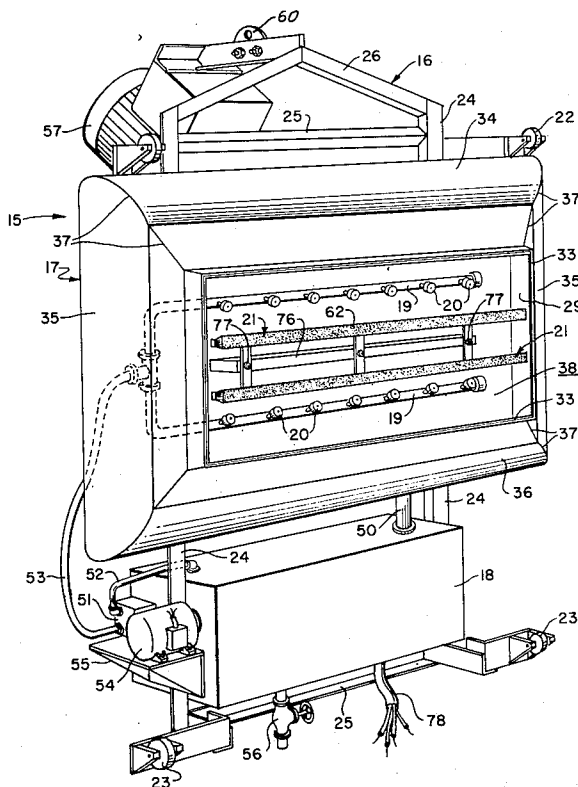
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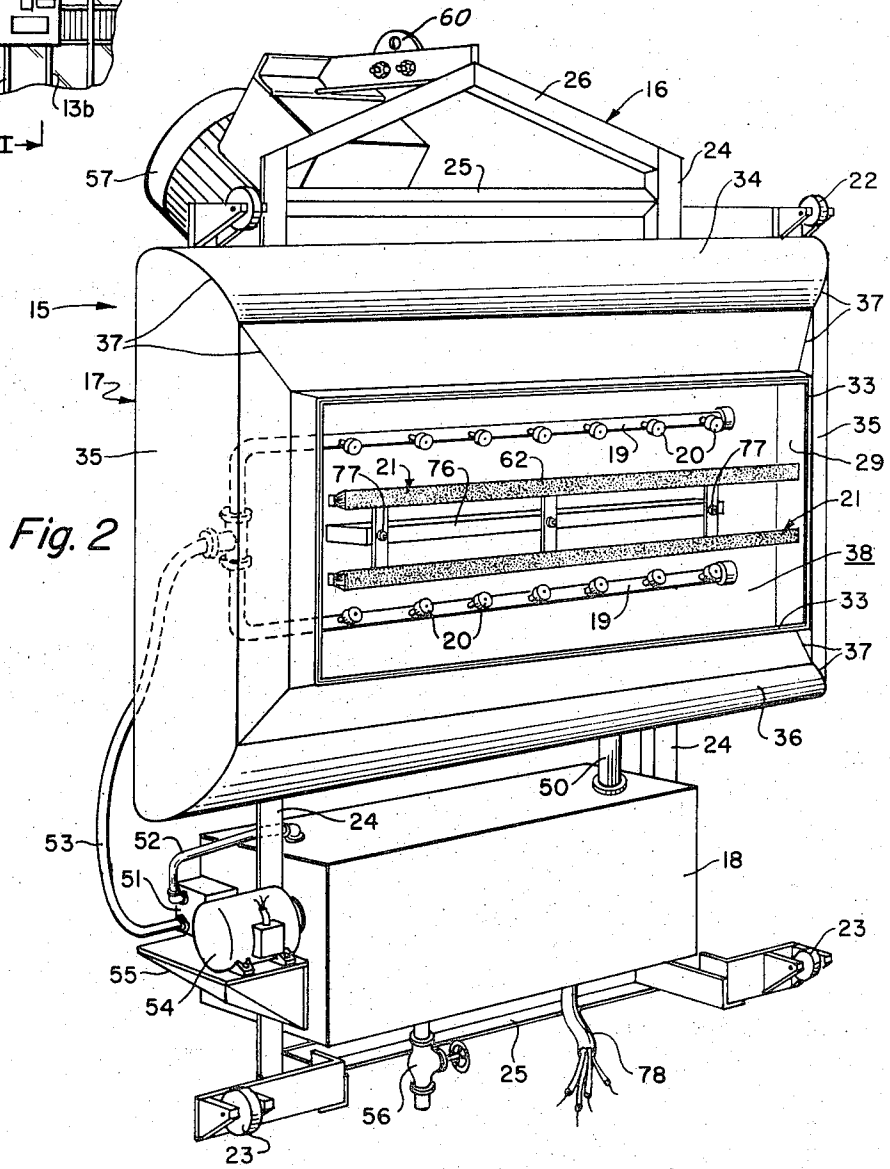
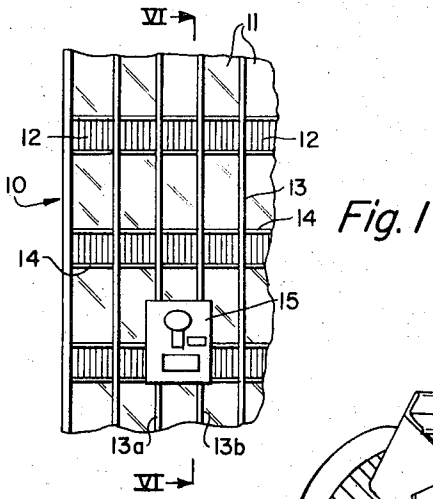
Primary Examiner—Harvey C. Hornsby
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[57] **ABSTRACT**

A wall washing device is provided with self contained liquid spray means, wall and window surface scrubbing means such as brushes or sponges and means for providing a curtain of high velocity, in-rushing air around a wall washing sight. This air serves to dry the freshly laundered wall and window surfaces and also to confine the washing liquids and retard their egress from the wall washing sight. The high velocity, in-rushing air curtain is delivered through a perimeter aperture which is spaced-apart from the window/wall surfaces, in accordance with a first embodiment; and is provided by forceably drawing atmospheric air inwardly at the perimeter of the wall washing sight in accordance with a second embodiment. The device is adapted to ascend and descend between a pair of vertical mullions of the building. The device is further adapted to provide its wall and window washing function during either the ascending or descending runs or both. The device moreover is intended for remotely controlled operation.

36 Claims, 17 Drawing Figures





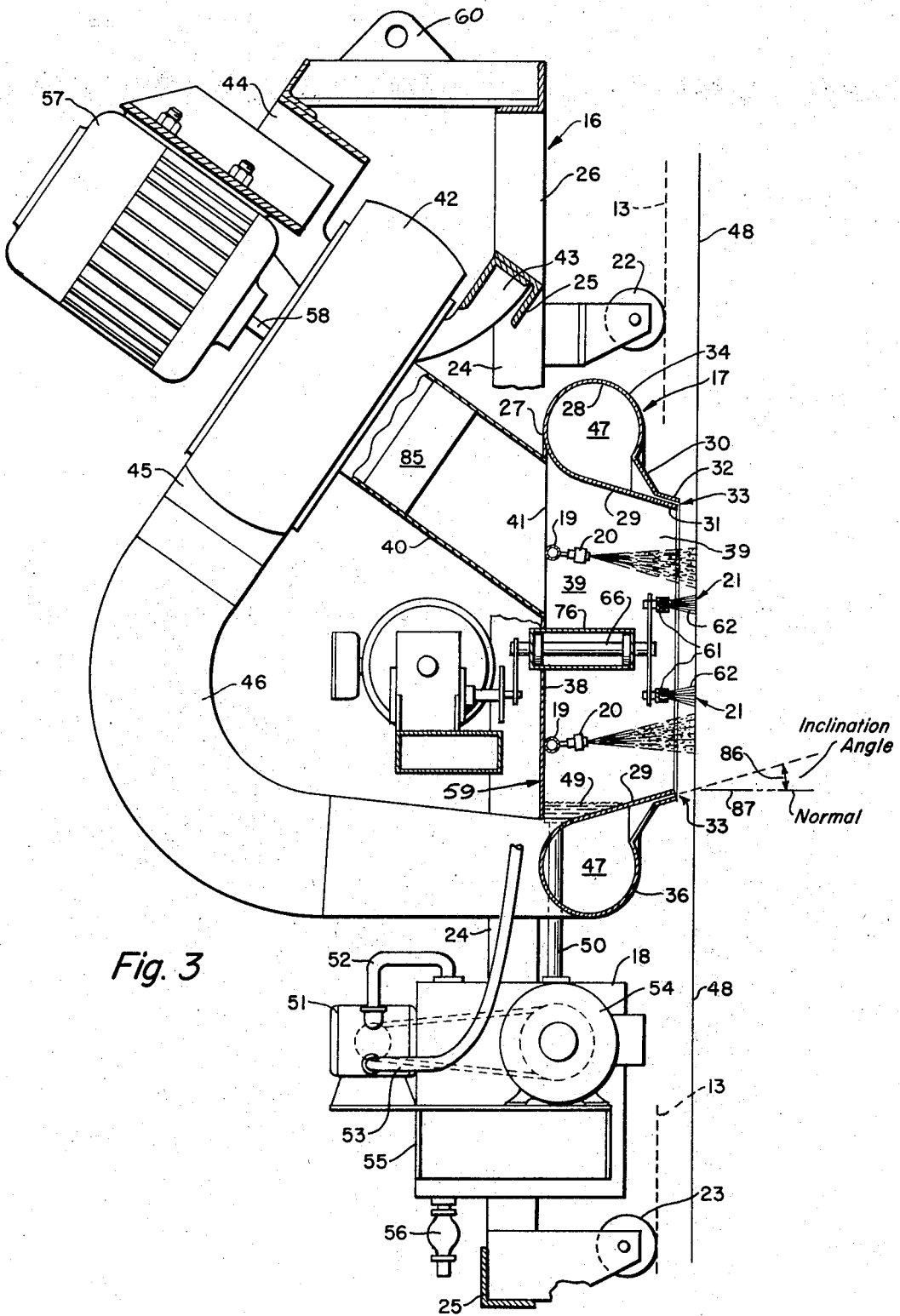


Fig. 3

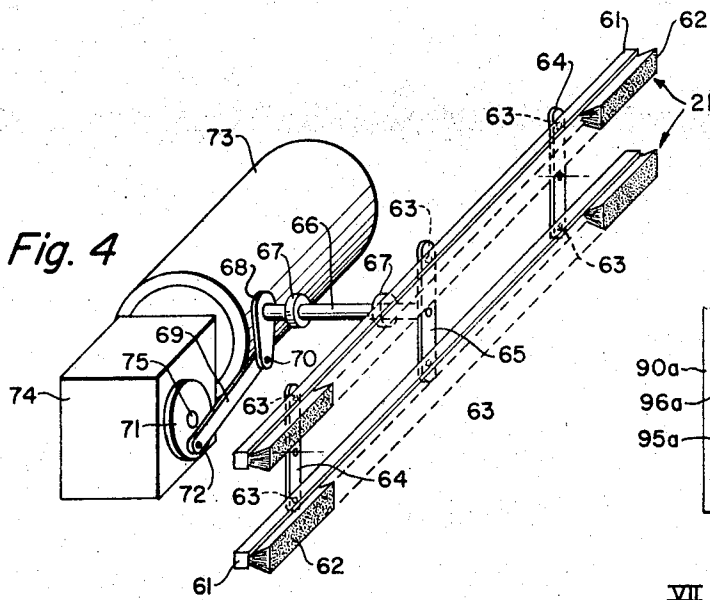


Fig. 4

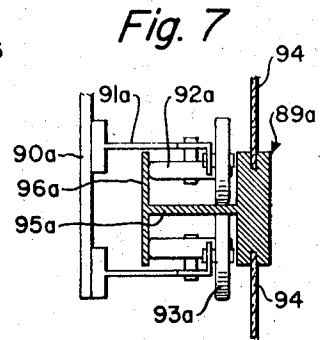


Fig. 7

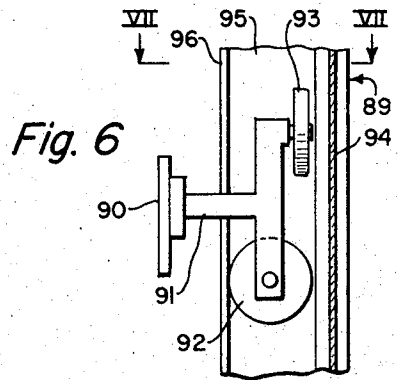


Fig. 6

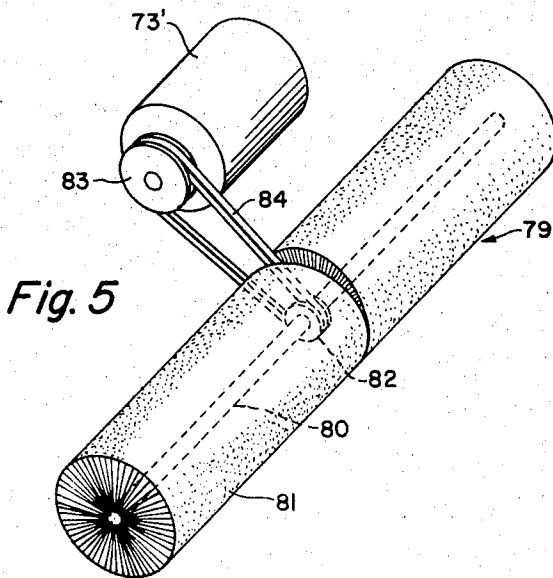


Fig. 5

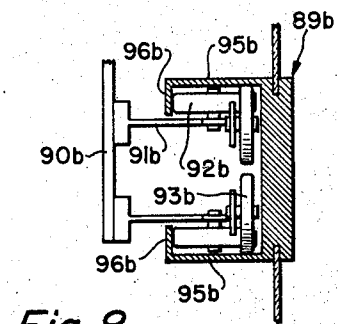
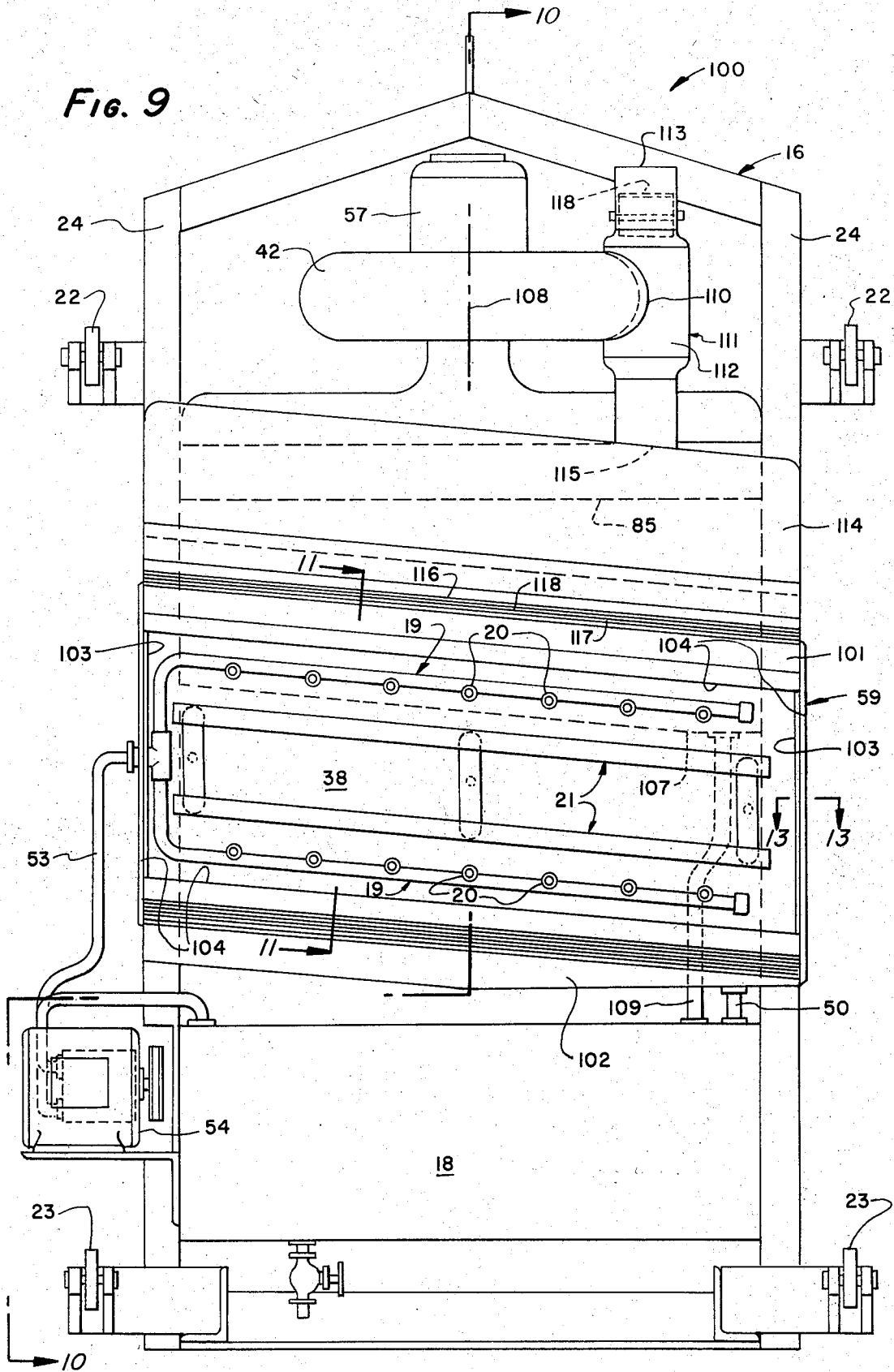


Fig. 8



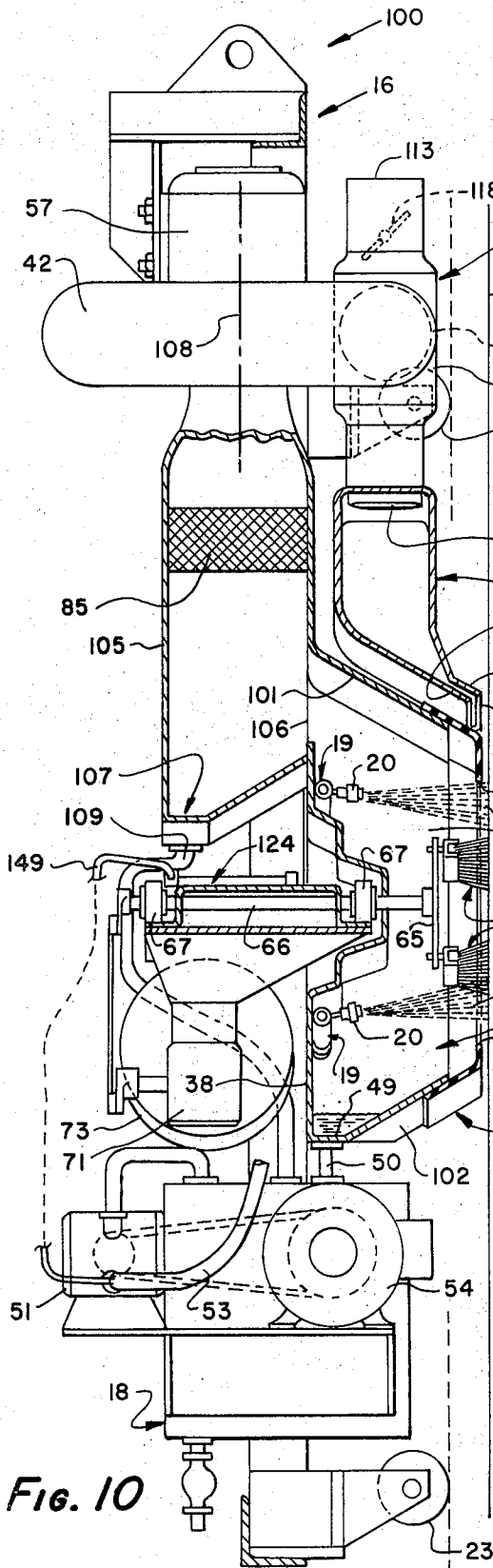


Fig. 10

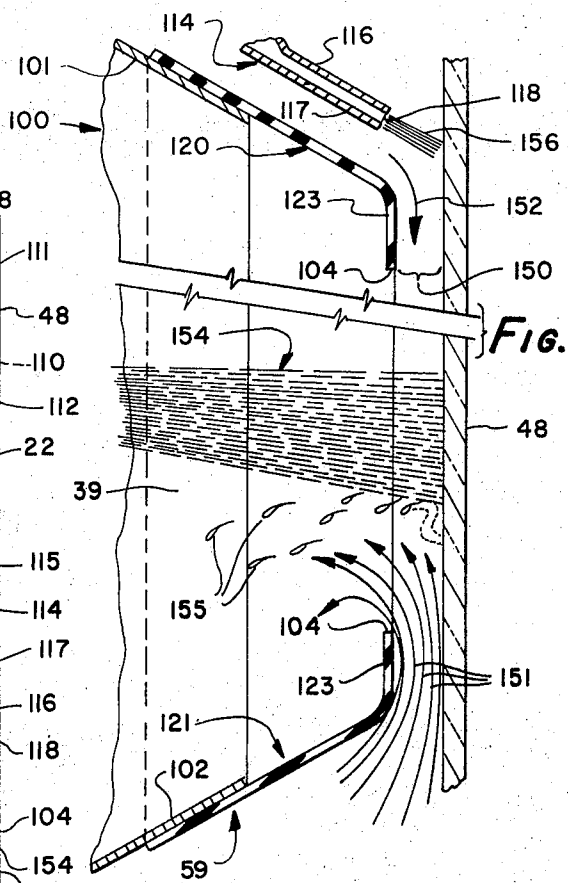


Fig. 11

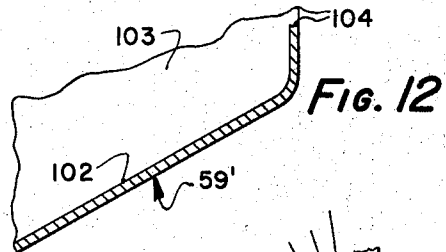


Fig. 12

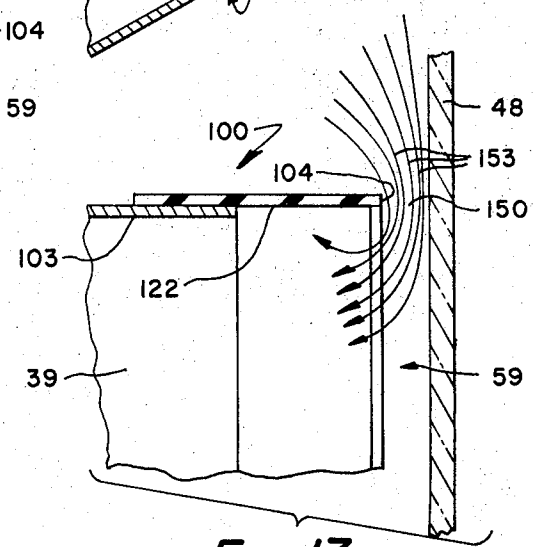
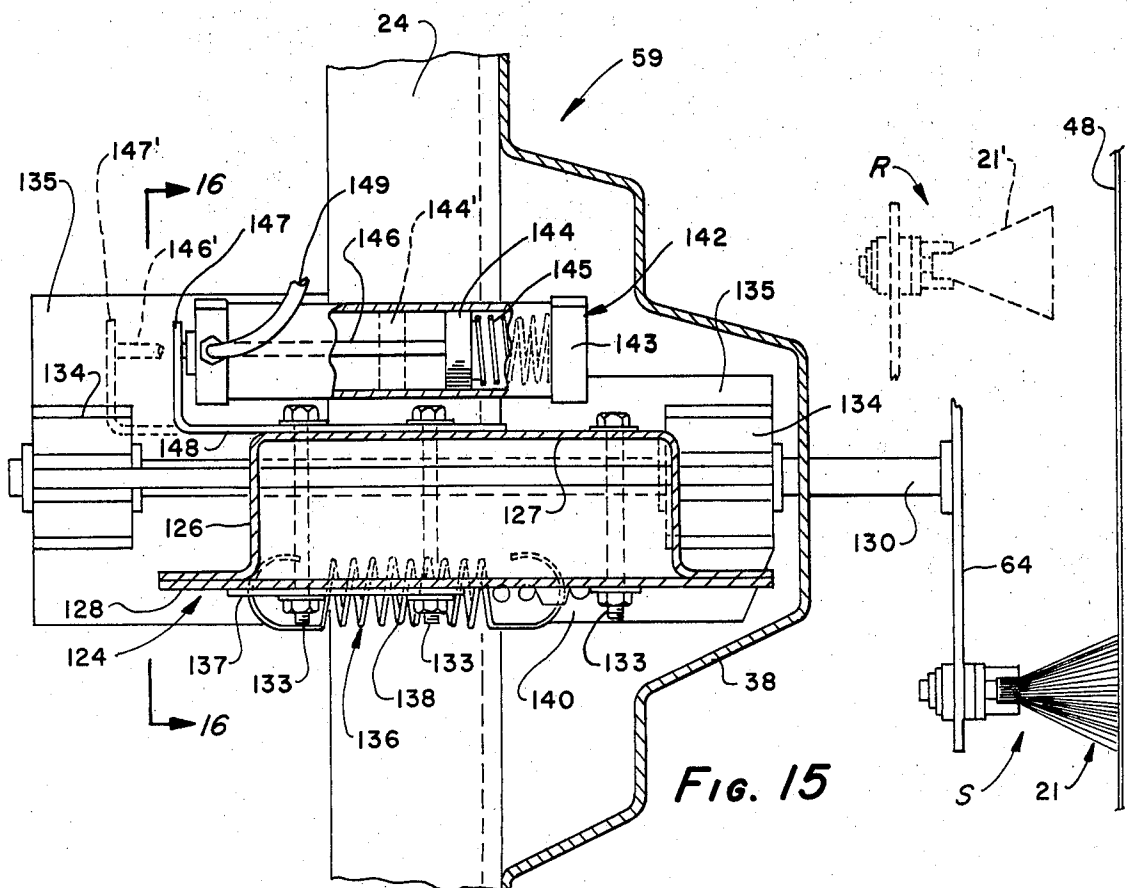
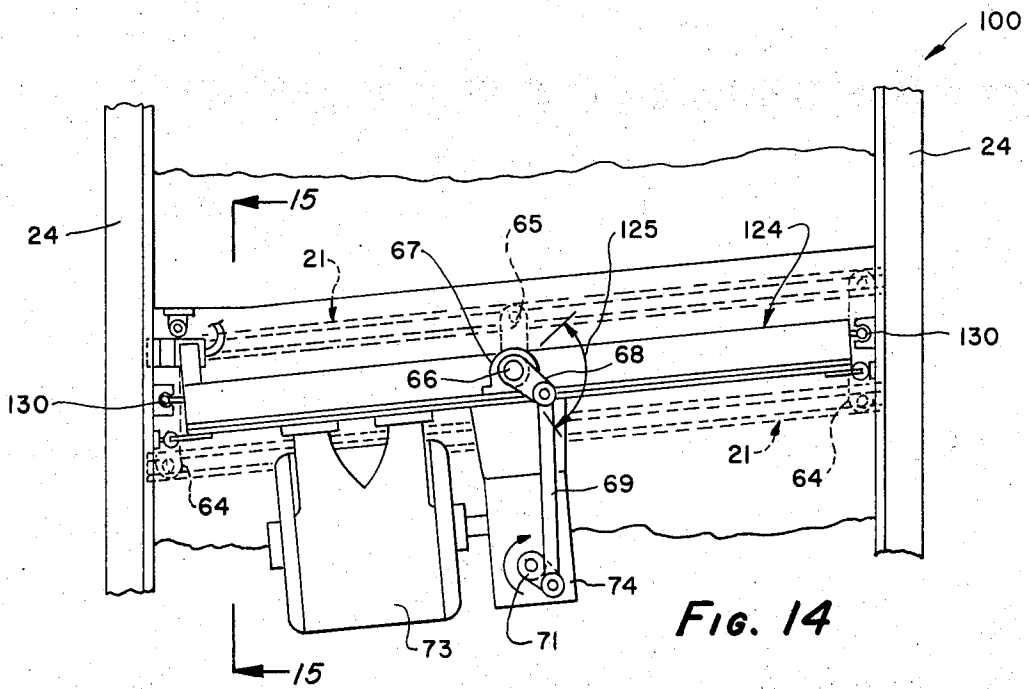
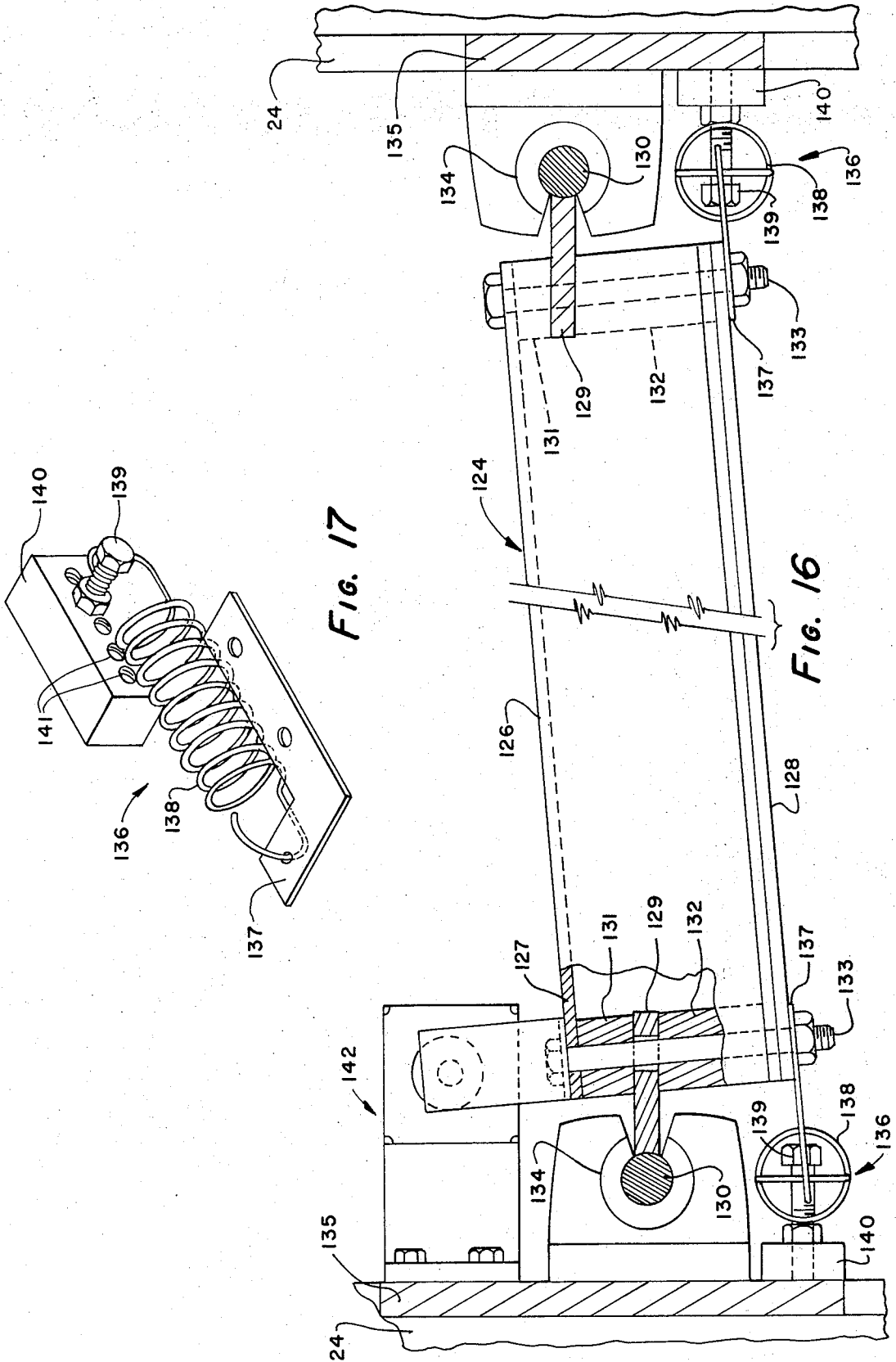


Fig. 13





WINDOW WALL WASHING DEVICE FOR HIGH-RISE BUILDINGS

CROSS REFERENCES TO RELATED APPLICATIONS

This application is a continuation-in-part of copending application Ser. No. 130,616 filed Apr. 2, 1971, now abandoned, and assigned to the assignee of this invention.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to window and wall washing devices for the exterior window and wall surfaces of high-rise buildings. More particularly the present invention concerns a unit which in operation is spaced apart from the exterior surfaces of the walls and windows of a high-rise building and which is provided with a perimeter air curtain to retard the egress of washing liquids from the space between the unit and the exterior window and wall surfaces.

2. Description of the Prior Art

High-rise buildings having fixed glazing are relatively new. Prior to the past decade, most, if not all, high-rise buildings employed movable glazing which permitted window cleaning to be conducted from the inside of the buildings. Within the past decade, fixed glazing has become popular and has created a need for other methods of washing the outside surfaces of the glazing. There is also a need for washing the outside surface of the infill panels between the fixed glazing in typical high-rise buildings. Numerous devices have been proposed for accomplishing the window washing 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 top 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 egress of cleaning liquid in the form of squeegee blades. Such devices are shown in U.S. Pat. No. 3,292,193 (LITTEN, Dec. 20, 1966); U.S. Pat. No. 3,298,052 (NOLFE, Jan. 1967); U.S. Pat. No. 3,425,082 (HETMAN, Feb. 4, 1969); U.S. Pat. No. 3,344,454 (MIKALSON, Oct. 3, 1967); U.S. Pat. No. 3,497,902 (HARTIGAN, Mar. 3, 1970). To date such devices have experienced only limited commercial acceptance

In some instances because of discontinuities in the building exterior surface unmanned wall-washing units have become immobilized at locations many floors above street level requiring hazardous rescue operations in high winds by workmen on scaffolds or ropes on the exterior of the buildings.

SUMMARY OF THE INVENTION

A mobile cleaning device for an exterior building wall is provided with a housing presenting a forward edge which defines a wall washing sight and which is spaced-apart from the building exterior wall. The device ascends or descends a defined portion (wall washing sight) of the wall between a pair of vertical mullions. The device includes suitably patterned spray means within the housing for directing cleaning liquids outwardly through the wall washing sight against the building exterior wall. The device includes agitating

means within the housing which extends through the wall washing sight into engagement with the building exterior wall for scrubbing the wall surface. The device further includes means for providing a high velocity, in-rushing air curtain around the wall washing sight to preclude substantial egress of cleaning liquids from the wall washing sight and to direct any cleaning liquids away from the building exterior wall surface back into the mobile cleaning device through the wall washing sight.

In accordance with one embodiment of this invention, the device is provided with a hollow perimeter duct defined in part by the boundary walls of the housing. The hollow perimeter duct includes a perimeter aperture which is spaced apart from the building exterior wall and which directs the aforesaid high velocity air curtain against the building exterior wall surface.

In accordance with an alternative embodiment of this invention, the housing presents a forward edge which is spaced apart from the building exterior wall surface. The aforesaid high velocity, in-rushing air curtain is provided by forceably drawing atmospheric air inwardly at the perimeter of the wall washing sight.

The housing provides an enclosed chamber extending rearwardly from the wall washing sight for recovering the cleaning liquids and for recovering a portion of the entrained air. From the enclosed chamber the cleaning liquids are recirculated for reuse through a liquid reservoir carried by the mobile cleaning device.

The air is withdrawn from the enclosed chamber at a relatively low velocity, through a moisture removing device. In the first embodiment, the air withdrawn from the enclosed chamber is recirculated through the hollow perimeter duct. In accordance with the alternative embodiment, all of the air withdrawn from the enclosed chamber may be vented directly to the atmosphere; or a major portion of the air withdrawn from the enclosed chamber may be directed to a hollow chamber through a linear aperture thereof to provide a second high velocity air curtain against the building exterior wall surface for drying the same.

Suitable building exterior wall engaging elements such as wheels are provided to engage the building mullions in a manner such that the desired spaced apart relationship between the perimeter frame and the window wall surface is maintained. It is a matter of choice whether (a) the mobile cleaning device is self-powered and driven by its own self-contained motive force or whether (b) the mobile cleaning device preferably is operated through a suitable cable drive mechanism which is provided at the top of the building and which includes cable connections between the drive mechanism and the mobile cleaning device. In the preferred embodiment, the weight of the mobile cleaning device does not include the prime mover required for mobility. Electrical power preferably is delivered to the device by means of cables associated with the driving cables for the device, although electrical power sources such as batteries of inertial prime movers (fly wheels) may be included with the device.

It is a feature of the first embodiment of the present mobile cleaning device that it can perform its building exterior wall washing function in either the ascending or the descending movement over the building exterior wall surface. It is intended that suitable transfer apparatus will be provided at the base of the building and at the top of the building to permit the transfer of a mo-

bile cleaning device from one location between the first pair of vertical mullions to a new location between a different pair of vertical mullions so that the device can perform its wall washing function in a semi-continuous fashion.

The alternative embodiment of the present mobile cleaning device performs its building exterior wall washing function during the descending movement over the building exterior wall surface. It is intended that suitable transfer apparatus will be provided at the top of the building to permit the transfer of the mobile cleaning device from one location between a first pair of vertical mullions to a new location between a different pair of vertical mullions.

As an alternative, either of the mobile cleaning devices may have self-contained apparatus for transferring the device into engagement with a different pair of vertical mullions. Means are provided within the mobile cleaning device for removing and replacing spent cleaning liquids from the liquid reservoir.

While an oscillating brush is provided as a preferred scrubbing means, it is contemplated that rotary brushes might be employed and further contemplated that oscillating or rotary sponges might be substituted for the brushes.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a fragmentary illustration of a typical modern high-rise building illustrating the present mobile cleaning device in a typical operating disposition;

FIG. 2 is a perspective illustration of the present mobile cleaning device as viewed from the building exterior wall surface;

FIG. 3 is a side elevation view partly in cross-section showing the present mobile cleaning device in operating relation to a building exterior wall surface;

FIG. 4 is an isometric illustration showing a preferred embodiment of the oscillating brush devices;

FIG. 5 is an isometric illustration showing an alternative embodiment of a rotary brush as a scrubbing means;

FIG. 6 is a fragmentary sectional view taken along the line VI—VI of FIG. 1 along the center line of a typical vertical mullion illustrating one mounting means;

FIG. 7 is a sectional view taken along the line VII—VII of FIG. 6 showing one embodiment of a mounting wheel system;

FIG. 8 is a sectional view similar to FIG. 7 showing an alternative embodiment of a mounting wheel system;

FIG. 9 is a front elevation illustrating an alternative embodiment of the present mobile cleaning device as viewed from the building exterior wall surface;

FIG. 10 is a cross-sectional view taken along the line 10—10 of FIG. 9, illustrating the mobile cleaning device in operating relation to a building exterior wall surface;

FIG. 11 is a fragmentary, broken, cross-sectional view taken along the line 11—11 of FIG. 9, illustrating upper and lower edge members of a housing, and the action of a high velocity, in-rushing air curtain on the washing liquids;

FIG. 12 is a fragmentary cross-sectional view illustrating an alternative housing edge member;

FIG. 13 is a fragmentary cross-sectional view taken along the line 13—13 of FIG. 9, illustrating an edge member of a housing;

FIG. 14 is a fragmentary rear view of the mobile cleaning device of FIG. 9, illustrating a movable carriage supporting a mechanism for oscillating brush devices;

FIG. 15 is a cross-sectional view taken along the line 15—15, further illustrating the movable carriage of FIG. 14;

FIG. 16 is a broken, fragmentary cross-sectional view taken along the line 16—16 of FIG. 15, illustrating linear brushings supporting the movable carriage; and

FIG. 17 is an isometric view of a typical, adjustable spring arrangement for urging the movable carriage toward the building exterior wall surface.

DESCRIPTION OF THE PREFERRED EMBODIMENT(S)

A typical modern building 10 is illustrated in FIG. 1 having an exterior wall consisting of windows 11 and infill panels 12 and horizontally spaced apart vertical mullions 13. Horizontal muntins 14 are normally provided at the juncture of the windows 11 and infill panels 12. Customarily the muntins 14 project outwardly from the plane of the exterior wall of the building 10. The windows 11 in modern high-rise buildings are customarily fixed glazing. The infill panels 12 are fabricated from a variety of materials some of which include porcelain-enameled aluminum sheets, porcelain-enameled steel sheets, anodized aluminum sheets, ceramic tile, fiber-reinforced resinous sheets, painted steel sheets, opaque glass sheets, slabs of marble, granite and other naturally occurring materials and synthetic simulations of marble, granite and natural materials, weathering steel sheets, painted steel sheets, stainless steel sheets, and the like.

The present mobile cleaning device 15 is positioned between a pair of adjacent vertical mullions 13a, 13b. By suitable means, not shown, but hereinafter described, the mobile cleaning device 15 is caused to ascend or descend over the exterior wall of the building 10 from top to bottom (or bottom to top) between each adjacent pair of vertical mullions in sequence.

According to FIG. 2, the mobile cleaning device 15 includes:

- a chassis 16;
- a hollow perimeter duct 17;
- a housing 59;
- a liquid reservoir 18;
- liquid manifolds 19 having plural spray nozzles 20;
- scrubbing means such as oscillating brushes 21;
- forwardly extending building engaging elements such as upper wheels 22 and lower wheels 23.

The chassis 16 includes vertical frame elements 24, horizontal frame elements 25 and inclined frame elements 26. The hollow perimeter duct 17 is secured to the vertical frame elements 24 in any suitable fashion as by bolts, rivets, welding. As better seen in FIG. 3, the hollow perimeter duct 17 is formed from sheet metal which is generally tubular and has a rounded portion 28, an interior wall portion 29 and an exterior wall portion 30. The interior wall portion 29 has a forward edge 31; the exterior wall portion 30 has a forward edge 32. The space between the forward edges 31, 32 constitutes a perimeter aperture 33. It will be observed in FIG. 2 that the perimeter aperture 33 forms an enclosed rectangle which defines the sight of the active washing accomplished by the present mobile cleaning device 15.

The hollow perimeter duct 17 is formed from four individual sheet metal components including a top member 34, two side members 35 and a bottom member 36. The members 34, 35, 36 are beveled at their ends and are smoothly connected preferably by means of welding seams 37 along the abutting beveled ends.

A vertical plate or rear wall 38 is provided along the back of the hollow perimeter duct 17 and is connected to the rounded portions 28 along its edges by means of suitable welds 27 one of which may be seen in FIG. 3 where the vertical plate 38 joins the top member 34. The interior wall portions 29 and the vertical plate 38 along with a portion of the rounded portions 28 constitute the boundary walls of the housing 59 which provides a chamber 39. An air removal conduit 40 communicates with the chamber 39 through an opening 41 in the vertical plate 38. The air removal conduit 40 feeds a centrifugal fan 42 at its inlet vortex. The centrifugal fan 42 is secured to the chassis 16 by means of suitable brackets 43, 44. The tangential air delivery opening 45 of the centrifugal fan 42 communicates with an air delivery conduit 46 which in turn communicates with the bottom member 36 of the perimeter duct 17. It will be observed the perimeter duct 17 has a continuous chamber 47 which serves as a pressurized air manifold to receive pressurized air from the conduit 46 and to release air at high velocities through the perimeter aperture 33. It will further be observed that the interior walls 29 and the exterior walls 30 are, in the region of their forward ends 31, 32 respectively, inclined with respect to the building exterior surface 48 indicated in FIG. 3.

It will further be observed that the inclined interior wall 29 of the bottom member 36 cooperates with the vertical plate 38 to form a trough 49 in which recovered cleaning liquid is collected from a drain tube 50 which communicates at its upper end with the trough 49 and communicates at its lower end with the reservoir 18. A liquid pump 51 draws cleaning liquid from the reservoir 18 through an inlet hose 52 and delivers cleaning liquid under pressure through a delivery hose 53 to a pair of manifold pipes 19 which are supported within the chamber 39 and are disposed generally parallel to each other and generally parallel to the forward edges 31 of the top member 34 and the bottom member 36. A plurality of suitable nozzles 20 is connected to each of the liquid manifolds 19. The spray patterns established by each of the nozzles 20 may be any suitable spray pattern found to be effective for the particular building exterior wall under consideration.

Referring to FIG. 3 the nozzles 20 direct a stream of the cleaning liquid outwardly through the sight against the exterior building wall surface 48. A suitable motor 54 is mounted along with the liquid pump 51 to a bracket 55 secured to a vertical member 24 of the chassis 16. A drain outlet 56 is provided at the base of the reservoir 18 to permit drainage of the liquid contents when desired.

A motor 57 has its rotatable drive shaft 58 connected to the impeller (not shown) of the centrifugal fan 42 and is mounted to the chassis 16 on a suitable bracket 44. The centrifugal fan 42 has its axis of rotation about the shaft 58 inclined with respect to the generally vertical plane of the perimeter aperture 33. The in-line air removal conduit 40 thus allows liquid condensate to return to the chamber 39 by gravity. The inclination of

the axis of rotation also permits minimizing the length of the air delivery conduit 46.

Brushes

The preferred scrubbing means for the present mobile cleaning device comprises a pair of reciprocating oscillating brushes 21. Each of the brushes 21 comprises a channel 61 filled with bristles 62. (See FIGS. 3,4). The two channels 61 are connected by means of pins 63 to idler side links 64 and to a driving center link 65. The driving center link 65 is centrally mounted to a shaft 66 confined within rigidly supported bearings 67 and connected in turn to a drive unit including a toggle arm 68 which is secured at the opposite end of the drive shaft 66, a connecting rod 69 which is pivotally connected to a pin 70 in the toggle arm 68 and also connected to a rotary drive disk 71 at an eccentrically mounted pin 72. A motor 73 is connected to a suitable gear reduction unit 74 to provide the desired rotating velocity of the output shaft 75 to which the rotary drive disk 71 is fastened. Thus it will be apparent that as the outward shaft 75 rotates unidirectionally, the center drive link 65 is caused to oscillate through an arc. This motion is translated through the connecting pin 63 to the channel 61 of the brushes 21 whereby they move from side to side in opposite directions. It will be observed from inspection of FIG. 3 that the brushes 62 extend forwardly beyond the sight defined by the forward edges 31 and actually engage the building exterior wall surface 48 to accomplish scrubbing of the surface. As a result of the disposition of the nozzles 20 above and below the brushes 21, the surface 48 is wetted before the brushes come into contact with the building surface 48 regardless of whether the mobile cleaning device is ascending or descending. Thus the bristles 62 do not engage a dry building surface which might cause objectionable abrasion, but instead contact only well flooded surfaces.

The bearings 67 preferably are rigidly mounted in a suitable bracket 76, see FIGS. 2,3 which is adequate to support the drive shaft 66 and to support the weight and stresses of the brush assembly in a cantilever fashion. It will be observed in FIG. 2 that the bracket 76 also provides for the rotatable support of mounting shafts 77 which extend through the centers of the side idler links 64.

Tracking and Movement

The present mobile cleaning unit is equipped with building engaging elements serving as spacing means for maintaining the housing 59 in spaced-apart relation from the exterior wall 48. The spacing means is illustrated as upper wheels 22 and lower wheels 23. It is intended that these wheels 22, 23 will engage tracks which may be the vertical mullions 13 of the building 10. Alternatively the tracks may constitute uninterrupted linear elements associated with the vertical mullions 13. In the preferred embodiment the wheels 22, 23 serve multiple purposes, i.e., (a) to maintain the space between the perimeter aperture and the window wall surface more-or-less constant so that the egress of cleaning liquids through this space can be retarded as a result of the high velocity air current directed against the window wall surface 48 through the perimeter aperture 33; (b) to maintain the present mobile cleaning device 15 in a frictional engagement with tracking elements associated with the vertical mullions 13; (c) to resist lateral thrusts due to wind loadings and seismic loadings; and (d) to resist the moment of the weight of

the wall washing unit. It is not intended that the wheels 22, 23 will serve as drive wheels. In the preferred embodiment, the present mobile cleaning device will be raised and lowered over a building exterior wall surface by means of tensioned cables which may be connected to the device through the apertured lug 60 or preferably will be hidden from view within recesses in the vertical mullions 13. Suitable driving connections of the cable variety are described in U.S. Pat Nos. 3,292,193; 3,298,052; 3,344,454; 3,497,902, supra.

Electrical power for driving the motors 57, 54, 73 is provided through the cable 78, FIG. 2.

The present mobile cleaning device may be moved by self contained drive elements. Such self contained drive units have been described in U.S. Pat. No. 3,425,082, supra. A self contained driving unit is not preferred because of the added weight which the driving elements introduce into the mobile cleaning device.

As an alternative embodiment in place of the oscillating brushes of FIG. 4, it is feasible to employ a unidirectional rotating cylindrical brush as shown in FIG. 5. The cylindrical brush 79 includes a central shaft 80 from which bristles 81 radiate. A centrally mounted drive pulley 82 is connected to the shaft 80. A drive motor 73' has a drive pulley 83 connected by means of a drive belt 84 to the drive pulley 82. Suitable deflectors (not shown) are provided to prevent the bristles 81 from interfering with the movement of the drive belt 84 in the manner described in U. S. Pat. No. 3,292,193, supra.

The embodiment illustrated in FIG. 5 is similar to that illustrated in FIG. 4 in that the bristles 81 project forwardly beyond the sight of the hollow perimeter frame into engagement with the building exterior wall surface 48. The cylindrical brush 79, if employed, is mounted between the two liquid manifold pipes 19 so that the sprays 20 are directed above and below the region of agitation resulting from the cylindrical brush 79.

If desired, a moisture removing device such as a demister 85 (FIG. 3) may be mounted within the air removal conduit 40 to reduce the quantity of entrained liquid carried forwardly into the vortex of the centrifugal fan 42.

Suitable filter devices (not shown) will be optional in the cleaning liquid recovery system and may be provided within the housing of the reservoir 18 for removing solids from the recirculating cleaning liquid. The recirculating cleaning liquid of course may be water alone or with suitable additives such as detergents, buffers and the like.

The air curtain not only serves to retard the egress of cleaning liquid from the space between the cleaning device and the building exterior wall but it also serves to dry the building exterior wall in the wake of the mobile cleaning device regardless of whether the unit is ascending or descending.

Because the sight is spaced-apart from the window wall, the horizontal mutins 14 do not create obstructions to the continuing movement of the cleaning device 15. With many of the mobile cleaning units of the prior art, wall engaging squeegees or sponges required abnormal depression in order to pass over protruding horizontal muntins. Frequently the force required to accomplish the necessary squeegee depression could not be generated and manual recovery of the mobile cleaning unit was required. The sponges or brushes of

the present wall washing device are thick enough, i.e., have sufficient bristle length or sponge thickness, to be pliant and thereby to accommodate wall protrusions without interference.

5 Operation

The perimeter aperture 33 has a thickness of 0.080 to 0.125 inch and develops a corresponding linear velocity of air of 244 to 156 feet per second. The pressure within the chamber 39 can be maintained at minus 1.00 to minus 1.25 inches of water (relative to atmospheric pressure) by means of the suction created by the withdrawal of recirculating air through the air conduit 40.

The liquid spray system preferably operates with a strainer having a retention for 100 mesh particles and a following filter having a retention of particles greater than 50 microns. Flat fan pattern nozzles are preferred having an equivalent orifice of 0.026 inches. The operating pressure preferably is about 150 psi.

The oscillating brush (FIG. 4) drive motor 73 generates a stroke varying from side to side from 2 to 3 inches. The brushes preferably have nylon bristles with bristle diameters of 0.008 inch.

The air knives or air curtains generated by the flow of high velocity air through the perimeter aperture 33 preferably is directed to converge at an inclination angle 86 from about 5 to about 20 degrees and preferably about 15 degrees with respect to the normal 87 (FIG. 3). A predetermined space between the forward edges 31 and the exterior surface of the building 48 is about three-fourths inch.

Mounting Systems

Typical mounting arrangements for the present wall washing unit are illustrated in FIGS. 6, 7, 8. In FIG. 6 there is illustrated a vertical mullion 89 and the frame 90 of the wall washing unit from which projects a wall mounting bracket 91 having first wheels 92 and second wheels 93. The vertical mullion 89 which includes web members 95 and flange members 96, may have a T-shaped profile as shown by the mullion 89a of FIG. 7 or may have a C-shaped profile as shown by the mullion 89b of FIG. 8. Glazing or infill panels 94 connect with the vertical mullions 89.

In FIG. 7, a web 95a of the mullion 89a joins flanges 96a to produce the T-shaped profile. A unit frame 90a has a pair of wheel mounting brackets 91a which secure first wheels 92a and second wheels 93a. The second wheels 93a rotate in a plane which is generally parallel to the flanges 96a and peripherally engage the web 95a. The first wheels 92a rotate in a plane which is generally parallel to the web 95a and peripherally engage either the inner surface of the flanges 96a or the outer surface of the mullion 89a. The diameter of the first wheels 92a is only slightly less than the space between the mullion 89a and the inner face of the flanges 96a.

In FIG. 8, a vertical mullion 89b has a C-shaped profile resulting from parallel webs 95b which terminate in inwardly directed flanges 96b. The wall washing unit frame 90b has a pair of wheel mounting brackets 91b on which are mounted first wheels 92b and second wheels 93b. The second wheels 93b rotate in the planes which are parallel to the flanges 96b and are peripherally engaged with the inner surfaces of the webs 95b. The first wheels 92b rotate in planes which are parallel to the webs 95b and peripherally engage either the inner surfaces of the flanges 96b or the outer surfaces of the mullions 89b. The diameter of the first wheels 92b is slightly less than the space between the outer sur-

face of the mullion 89b and the inner surface of the flanges 96b.

It will be observed that the mounting means of FIGS. 6, 7, 8 restrict movement of the wall washing unit from side-to-side and movement toward-and-away from the mullions 89. The wall washing unit at the top of the building is pulled upwardly apart from the tops of the mullions 89 and transported laterally to a different set of vertical mullions for the similar connection. At the bottom of the building, the wall washing unit may be pulled downwardly apart from the pair of vertical mullions 89 and moved laterally to engage a different set of vertical mullions in the same manner.

An alternative embodiment of the present mobile cleaning device is illustrated in FIGS. 9 through 17 inclusive and is identified generally by the numeral 100. Corresponding numerals will be employed to identify corresponding parts heretofore described.

According to FIGS. 9 and 10, the mobile cleaning device 100 includes a housing 59 supported by and extending forwardly of the vertical frame elements 24 of the chassis 16. The housing 59 is defined by upper and lower inclined boundary walls 101, 102, side boundary walls 103 and a rear wall 38. The boundary walls 101, 102, 103 and the rear wall 38 defined a chamber 39. It will be observed in FIG. 9 that the housing 59 presents forward edges 104 forming an enclosed rectangle which defines the sight of active washing accomplished by the present mobile cleaning device 100. It will be observed in FIG. 10 that the nozzles 20 of the liquid manifolds 19 direct liquid sprays 154 through the sight against the building exterior surface 48; and that the oscillating brushes 21 extend through the sight into engagement with the building exterior surface 48. The recovered cleaning liquid accumulates in the trough 49 and is returned to the reservoir 18 through the drain tube 50.

It will be observed in FIG. 10 that a vertically presented air removal conduit 105 communicates with the chamber 39 through an opening 106. The upper end of the air removal conduit 105 communicates with the inlet of fan means which preferably comprises a centrifugal fan 42 driven by a motor 57. The fan 42 has an axis of rotation 108 which is vertically presented and parallel with the generally vertical plane of the sight. An entrained liquids removing device such as a demister 85 is mounted within the air removal conduit 105 above the opening 106. The air removal conduit 105 has a trough-shaped bottom 107 for accumulating liquids removed by the demister 85. The recovered liquids are returned to the reservoir 18 through a second drain tube 109.

The centrifugal fan 42 presents a discharge opening 100 communicating with second conduit means 111. It will be observed in FIGS. 9 and 10 that the second conduit means 111 comprises a conduit segment 112 having an upper outlet opening 113 communicating with the atmosphere for discharging gases extracted from the chamber 39. If desired, the mobile cleaning device 100 may be provided with a duct 114 extending across the top of the housing 59 and communicating with the conduit segment 112 through a lower outlet opening 115. The duct 114 presents an upper forward edge 116 and a lower forward edge 117. The space between the forward edges 116, 117 provide second aperture means 118 positioned outboard of the sight for delivering a supplementary curtain of high velocity, drying gas at a

suitable inclination angle against the building exterior surface 48, as will be described. Proportioning valve means 119 may be provided within the second conduit means 111 preferably above the fan discharge opening 110, for controlling the volume of extracted gas delivered to the second aperture means 118.

It will be observed in FIGS. 11 and 13, that the housing 59 is provided with flexible forward portions in the form of upper and lower resilient rails 120, 121 (FIG. 11) secured to the upper and lower walls 101, 102, respectively; and resilient side rails 122 (FIG. 13) secured to the side walls 103 of the housing 59. It will be observed in FIG. 11 that the upper and lower rails 120, 121 include inturned flanges 123 presenting the forward edges 104. Alternatively, the housing 59' (FIG. 12) may present rigid forward portions constituting extensions of the walls of the housing 59'.

Referring to FIGS. 10, 14 and 15, the mobile cleaning device 100 is provided with platform means 124 for supporting the mechanical scrubbing elements (brushes 21) for reciprocal movement through the sight between a scrubbing position S (FIGS. 10 and 15) and a retracted position R — see dotted outline position in FIG. 15 — wherein the brushes 21 are spaced from the scrubbing position S and the building exterior surface 48. It will be observed in FIGS. 10 and 14 that the drive motor 73 and gear reduction unit 74 are secured to and movable with the platform means 124. As best shown in FIG. 10, the drive shaft 66 connected to the driving center link 65, is confined within the support bearings 67 which, in turn, are secured to the opposite sides of the platform means 124. The driving connection between the drive shaft 66 and the gear reduction unit 74 is similar to that drive connection illustrated in FIG. 4 and includes the toggle arm 68, the rotary drive disc or arm 71, and the connecting rod 69. The driving connection of FIG. 14 is such that as the rotary drive arm 71 rotates unidirectionally, the center drive link 65 is caused to oscillate through the arc indicated at 125, whereby the brushes 21 are moved from side to side in opposite directions.

It will be observed in FIGS. 15 and 16 that the platform means 124 may be assembled from a hat-shaped upper sheet 126 presenting a top wall 127 and a flat lower sheet 128. As best shown in FIG. 16, each of the opposite ends of the platform means 124 is supported by a horizontal plate 129 having one of its longitudinal edges secured to a shaft 130 and its opposite longitudinal side portion disposed between upper and lower clamp blocks 131, 132. The clamp blocks 131, 132 are disposed between the confronting faces of the top wall 127 and the flat lower sheet 128. The block 131, 132 and the plate 129 are rigidly secured to the platform means 124 by plural fasteners 133 (FIG. 15).

It will be observed in FIGS. 15 and 16 that each of the shafts 130 is supported for longitudinal reciprocation by a pair of journal means, such as linear bushings 134. The linear bushings 134 are secured to support plates 135 attached to the vertical frame elements 24. Each of the shafts 130 has an end projecting through the rear wall 38 of the housing 59 and supporting one of the idler side links 64.

A platform means 124 is provided with resilient means 136 for urging the mechanical scrubbing elements (brushes 21) through the sight into the scrubbing position S (FIG. 15). Referring to FIGS. 16 and 17, the resilient means 136 may comprise an arm 137 secured

to the platform means 124 by means of the fasteners 133. A block 140 having spaced-apart threaded openings 141 is secured to the vertical frame member 24. A bolt 139 is introduced into a selected one of the threaded openings 141. A spring 138 has one of its ends hooked over the bolt 139 and its opposite end connected to the arm 137. The tension provided by the spring 138 may be adjusted by introducing the bolt 139 into another one of the threaded openings 141. It will be observed in FIG. 15 that the block 140 is positioned between the arm 137 and the brushes 21. Thus, the spring 138 urges the platform means 124 toward the building exterior surface 48.

The platform means 124 also is provided with motor means 142 (FIGS. 15 and 16) for moving the mechanical scrubbing elements 21 to the retracted position R (FIG. 15). It will be observed in FIG. 15 that the motor means 142 may comprise a fluid operated cylinder 143 having a piston 144 biased in a direction away from the building exterior surface 48 by a spring 145. A piston rod projects from the cylinder 143 into engagement with an upstanding arm 147 of an angle member 148. The angle member 148 is secured to the top wall 127 of the platform means 124 by the fasteners 133. The cylinder 143 includes an inlet hose 149 for introducing fluids under pressure to displace the piston 144 in the direction which compresses the spring 145. With the spring 145 in the compressed condition illustrated in FIG. 15, the resilient means 136 contracts and urges the mechanical scrubbing elements 21 into engagement with the building exterior surface 48.

In the preferred arrangement (FIG. 10) the opposite end of the inlet hose 149 communicates with the delivery hose 53 — the delivery hose 53 being connected to the liquid manifolds 19 (FIG. 9). Thus, when the liquid pump 51 is activated, liquid under pressure is communicated to the manifolds 19 while simultaneously being communicated to the motor means 142. Hence, the mechanical scrubbing elements 21 are urged into engagement with the building exterior surface 48 as the nozzles 20 direct the liquid sprays 154 against the building exterior surface 48. Thus it can be stated that the motor means 142 is responsive to reduced liquid pressures in the liquid distributing means (manifolds 19). At the termination of a washing cycle, the liquid pump 51 is deactivated whereby the liquid pressure within the delivery hose 53 and the inlet hose 149 is reduced. At that time, the piston and piston rod will be moved to the dotted outline positions 144', 146' (FIG. 15) under the influence of the spring 145 — the upstanding arm likewise being displaced to the 147' position thereby retracting the platform means 142 and the brushes to the retracted position R.

Operations

Referring to FIGS. 11 and 13, the forward edges 104 of the housing 59 are maintained spaced apart from the building exterior surface 48 to provide a gap 150 of approximately one-fourth to three-eighths of an inch. The pressure within the chamber 39 can be maintained at minus 9 to minus 12 inches of water (relative to atmospheric pressure) by means of the suction created by the centrifugal fan 42 (FIG. 10). The suction causes atmospheric air to be forceably drawn into the chamber 39 through the gap 150 as high velocity, in-rushing air curtains illustrated schematically by the arrows 151, 152 (FIG. 11) and 153 (FIG. 13). The suction within

the chamber 39 develops a corresponding linear air velocity at the gap 150 of 80 to 100 feet per second.

It will be observed in FIG. 11 that impingement of the liquid spray 154 against the building exterior surface 48 creates liquid drops 155 which, in the absence of the curtain 151, would descend along the surface 48. However, the high velocity in-rushing air curtain 151 precludes the egress of the liquid drops 155 from the wall washing sight and carries them into the chamber 39 to the trough 49 (FIG. 10).

The mobile cleaning device 100 performs its wall washing function during the descending movement over the building exterior surface 48. Suitable transfer apparatus (not illustrated) will be provided at the top of the building to permit the transfer of the mobile cleaning device from one location between a first pair of vertical mullions to a new location between a different pair of vertical mullions.

It will be noted that the curtains 151, 153 between the lower resilient rail 121 and the resilient side rails 122 serve to retard the egress of cleaning liquids from the sight through the gap 150. As the mobile cleaning device 100 descends, the curtain 152 between the upper resilient rail 120 and the building exterior surface 48 serves to dry the building exterior surface 48 in the wake of the mobile cleaning device 100. To assist in drying the building exterior surface 48, the second aperture means 118 (FIG. 11) may be provided to direct a supplementary high velocity air curtain 156 against the building exterior surface 48 in the wake of the mobile cleaning device 100.

I claim:

1. In a building exterior wall washing device, the combination of
 - a housing comprising
 - a boundary wall having a forward edge, and
 - a rear wall cooperating with said boundary wall to define a chamber;
 - a sight disposed in an essentially vertical plane defined by the said housing and being essentially unobstructed at the said forward edge of said housing;
 - liquid distributing means within said chamber for directing liquid through the said sight;
 - spacing means for maintaining the said housing in a spaced-apart relation from the said exterior wall;
 - means for providing a high velocity in-rushing gas curtain at the said forward edge of the said housing to preclude substantial egress of said liquid between the said forward edge and the said exterior wall;
 - means for removing liquid from said chamber; and
 - conduit means for extracting at least a portion of the said gas from the said chamber.
2. The device of claim 1 wherein said spacing-means comprises mullion engaging elements which maintain the said sight at a selected distance from the said exterior wall.
3. The device of claim 1 wherein said means for providing a high velocity in-rushing gas curtain comprises a hollow perimeter duct defined in part by the said housing and extending around the said housing;
- aperture means disposed along said forward edge of the said housing and communicating with the said hollow perimeter duct outboard of said site; and
- delivery means for delivering gas through said aperture means and at a suitable inclination angle as said gas curtain.

4. The device of claim 3 wherein the said inclination angle of the said gas curtain converges at an angle from about 5° to about 20° with respect to the normal.

5. The device of claim 3 wherein the said delivery means for delivering gas is connected to the said conduit means whereby at least a portion of the said gas delivered through the said aperture means is recirculated through the said delivery means.

6. The device of claim 5 wherein the said delivery means is a centrifugal fan.

7. The device of claim 6 wherein the said centrifugal fan has an axis of rotation inclined with respect to the generally vertical plane of the said sight.

8. The device of claim 5 wherein a moisture removing device is disposed within the said conduit means between the said chamber and the said delivery means.

9. The device of claim 1 wherein the said device includes mechanical scrubbing elements positioned within the said chamber and having wall engaging elements extending forwardly through the said sight to engage the said exterior wall.

10. The device of claim 9 wherein the said mechanical scrubbing elements are mounted for oscillation in a generally horizontal locus.

11. The device of claim 9 wherein the said mechanical scrubbing elements are rotatable about an axis which is generally horizontal and is also generally parallel with the generally vertical plane of the said sight.

12. The device of claim 9 wherein the said mechanical scrubbing elements are bristle containing brushes.

13. The device of claim 9 wherein the said liquid distributing means are disposed both above and below the said mechanical scrubbing elements.

14. The device of claim 9 including platform means for supporting said mechanical scrubbing elements for reciprocal movement through the said sight between a scrubbing position and a retracted position spaced from the said scrubbing position; and resilient means for urging the said mechanical scrubbing elements through the said sight into the said scrubbing position.

15. The device of claim 14 including motor means operable at the termination of a washing cycle for moving the said mechanical scrubbing elements to the said retracted position.

16. The device of claim 14 including motor means responsive to reduced liquid pressure within said liquid distributing means for moving the said mechanical scrubbing elements to the said retracted position.

17. The device of claim 1 wherein said means for providing high velocity in-rushing gas curtain comprises fan means connected to the said conduit means for evacuating the said chamber whereby atmospheric air is forceably drawn between the said forward edge of the said housing and the said exterior wall, into the said chamber as the said high velocity, in-rushing gas curtain.

18. The device of claim 17 wherein the said fan means is a centrifugal fan.

19. The device of claim 18 wherein the said centrifugal fan has an axis of rotation parallel with the general vertical plane of the said sight.

20. The device of claim 17 including

second conduit means for extracting at least a portion of the gas discharged from the said fan means; and

second aperture means disposed above and outboard of the said sight and communicating with the said second conduit means for delivering a supplementary high velocity gas curtain at a suitable inclination angle against the said exterior wall.

21. The device of claim 20 wherein the said second conduit means includes

a discharge opening communicating with the atmosphere; and proportioning valve means for controlling the volume of extracted gas delivered to the said second aperture means.

22. The device of claim 17 wherein an entrained liquids removing device is disposed within the said conduit means between the said chamber and the said fan means.

23. The device of claim 1 wherein said boundary wall of the said housing presents flexible forward portions at the said sight.

24. The device of claim 1 wherein the said boundary wall of the said housing presents rigid forward portions at the said sight.

25. In a building exterior wall washing device, the combination of

a perimeter duct; a sight disposed in an essentially vertical plane defined by said perimeter duct; a chamber defined in part by said perimeter duct and extending rearwardly of said sight; liquid distributing means within the said chamber for directing liquid through the said sight; said sight being essentially unobstructed at the forward side of said perimeter duct; spacing means for maintaining the said perimeter duct in spaced apart relation from the said exterior wall;

aperture means disposed along the forward side of the said perimeter duct and communicating with the said perimeter duct outboard of the said sight; delivery means for delivering gas through said aperture means at a suitable velocity and inclination angle so as to preclude substantial egress of said liquid between the said perimeter duct and the said exterior wall;

means for removing liquid from said chamber; and conduit means for extracting at least a portion of the said gas from the said chamber.

26. The device of claim 25 wherein the said delivery means for delivering gas is connected to the said conduit means whereby at least a portion of the said gas delivered through the said aperture means is recirculated through the said delivery means.

27. The device of claim 26 wherein the said delivery means is a centrifugal fan.

28. The device of claim 27 wherein the said centrifugal fan has an axis of rotation inclined with respect to the generally vertical plane of the said sight.

29. The device of claim 26 wherein a moisture removing device is disposed within the said conduit means between the said chamber and the said delivery means.

30. The device of claim 25 wherein the said device includes mechanical scrubbing elements positioned within the said chamber and having wall engaging ele-

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ments extending forwardly through the said sight to engage the said exterior wall.

31. The device of claim 30 wherein the said mechanical scrubbing elements are mounted for oscillation in a generally horizontal locus.

32. The device of claim 30 wherein the said mechanical scrubbing elements are rotatable about an axis which is generally horizontal and is also generally parallel with the generally vertical plane of the said sight.

33. The device of claim 30 wherein the said mechanical scrubbing elements are bristle containing brushes.

34. The device of claim 30 wherein the said liquid

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distributing means are disposed both above and below the said mechanical scrubbing elements whereby the device will perform its wall washing function during both ascending and descending movement.

5 35. The device of claim 25 wherein said spacing means comprises mullion engaging elements which maintain the said sight at a selected distance from the said exterior wall.

10 36. The device of claim 25 wherein the said inclination angle of the gas converges at an angle from about 5° to about 20° with respect to the normal.

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