United States Patent [19]

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[54] SPRAY CLEANING SYSTEM

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[52] **U.S. Cl.** **134/64,** 134/154, 134/199

[51] **Int. Cl.** **B08b 3/02**

[58] **Field of Search**.....134/48, 49, 64, 70, 134/72, 82, 83, 131, 151, 165, 199, 154, 122

[56] **References Cited**

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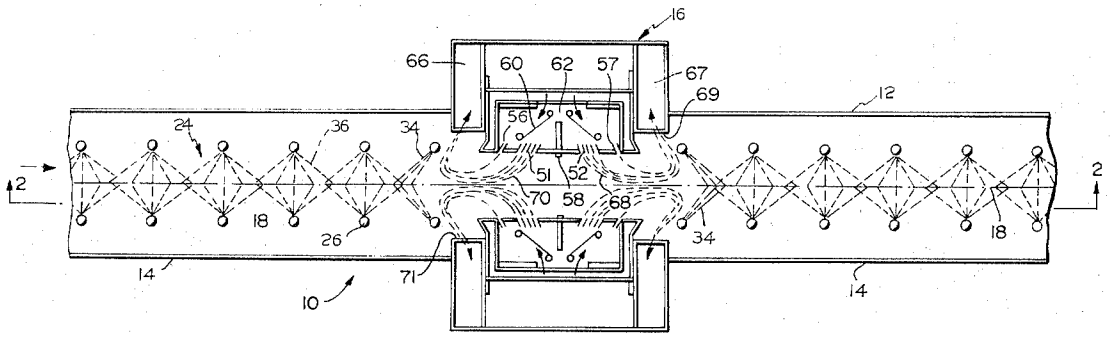
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[57] **ABSTRACT**

A spray cleaning system adapted to operate upon elements of extended length including a confined area having a path of travel along which the elements are conveyed, a plurality of spray stations each having spraying units aligned on either side of the path of travel, and a pneumatic isolating station positioned between successive spray stations to direct a flow of air upon the surfaces of the elements at a low velocity to prevent cross contamination between liquids sprayed in successive spray stations.

19 Claims, 4 Drawing Figures



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SHEET 1 OF 2

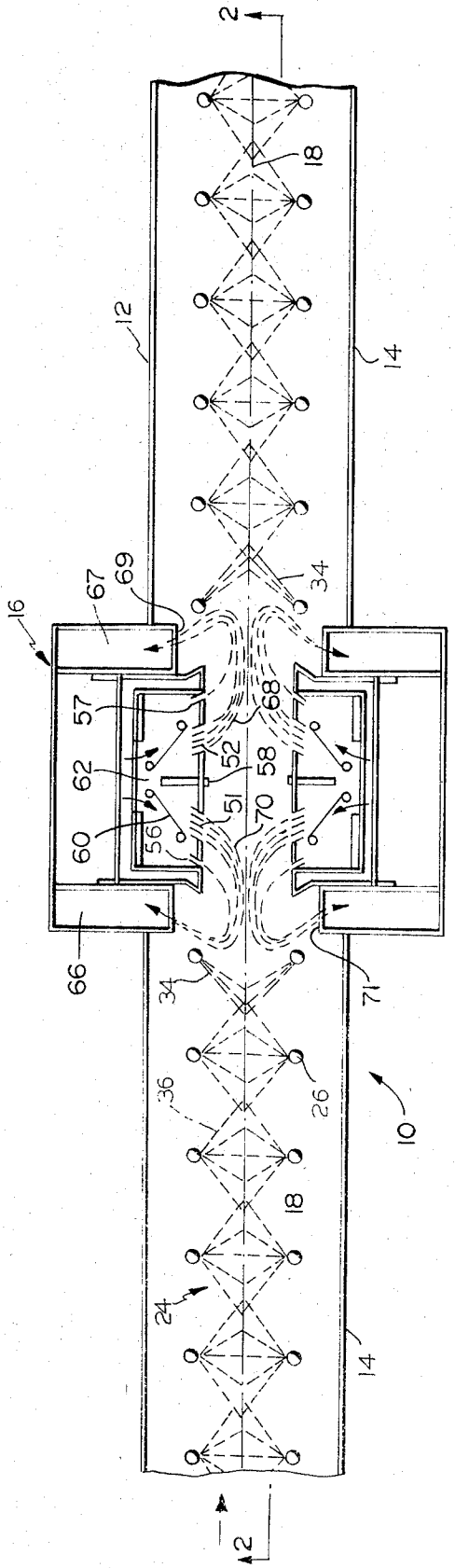


FIG. 1

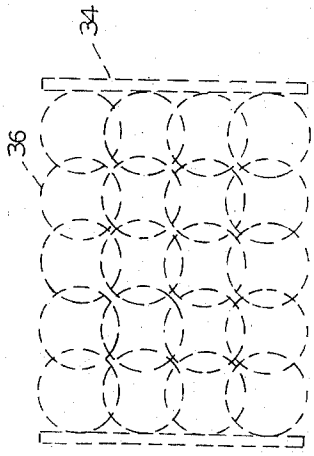


FIG. 3

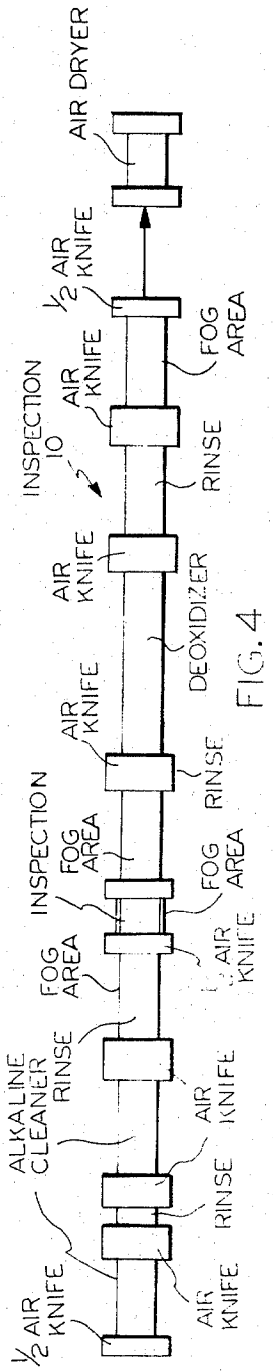


FIG. 4

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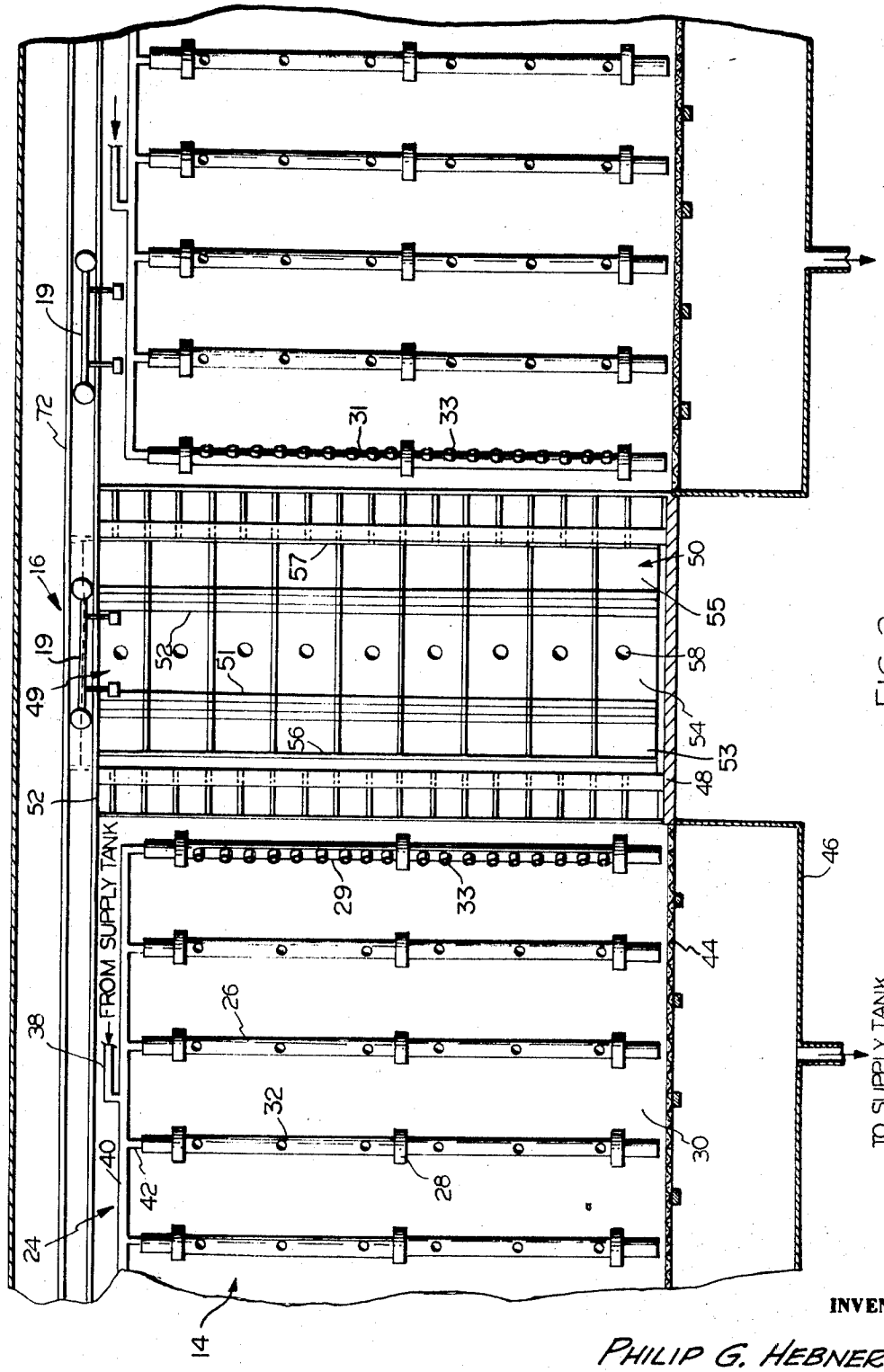


FIG. 2

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SPRAY CLEANING SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention pertains to spray cleaning systems and more particularly to such systems for use in cleaning elements of extended length.

2. Discussion of the Prior Art

Prior to galvanization, painting or other processing of metal and other materials, it is desirable to first clean the material. The cleaning operation has traditionally taken place in tanks containing various chemical solutions into which the metal is dipped. The cleaning of metal is extremely important, especially in aircraft manufacture where extensive use is made of such metals as aluminum, titanium, and stainless steel. These metals must be carefully cleaned before they are either bonded to other pieces of metal or otherwise treated or coated. Conventional dip tank systems have the disadvantage that as the metal element is moved through various treatment stages, the element must be placed in each bath successively, drained, washed and put into a following system in an intermittent operation. Another disadvantage of conventional dip tank systems is that the tanks must be longer than the element, and very substantial quantities of chemical solution are required.

In order to avoid the above disadvantages continuous spray cleaning systems have been developed in the last five to six years wherein the element to be cleaned is hooked onto a conveyor system and passed through an enclosure where the element is subjected to various chemical treatments. To date, however, such spray cleaning systems have been limited to the cleaning of very small elements to prevent exposure to different solutions simultaneously. That is, in treating very long elements, the element will be exposed to one, two or even three different spray solutions at the same time; and, thus, while one portion of the element is being treated with a caustic cleaner, another portion might be etched with an acid solution or other reagent.

In order to render such systems effective, a successful means must be devised to prevent one solution from being carried into the succeeding solution. Even if the solution being carried over is successfully washed off, the loss of reagent is a severe disadvantage, so such systems must be built in such a way that cross contamination is eliminated while as little as possible of the valuable reagents are washed down the drain with the wash water.

Various attempts have been made to keep the solutions separated by having air blow across the enclosure at various convenient points so that the solution would be blown off the conveyed sheet. These attempts, however, have not proven entirely successful because they have been based on the principle of high velocity air flow, and high velocity air, with nothing more, has a tendency to cause turbulence and swirling air streams which in turn result in significant losses of reagent solutions and excessive swaying and slamming of elements into tunnel walls and internal spray structure.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a spray cleaning system for use with elements of extended length, which system isolates successive spray stations without wasting spray liquids or damaging the elements.

The present invention is generally characterized in a spray cleaning system for cleaning elements of extended length including a plurality of spray stations arranged to define a path of travel for the elements and a pneumatic isolating station disposed in the path of travel between successive spray stations and directing air on the elements to provide a low velocity, laminar air flow whereby liquids sprayed in the successive spray stations are isolated from each other.

Another object of the present invention is to provide an apparatus for spray cleaning a continuous sheet or strip material in which cross contamination between various spray liquids is minimized.

A further object of the present invention is to construct a spray station providing a flat sheet of liquid at the entrance thereof to thoroughly wet the surfaces of an element.

The present invention has another object in that a spray station has flat spray nozzles on either end to facilitate liquid isolation and to reduce the quantity of liquid required to treat an element.

Another object of the present invention is to construct a pneumatic isolating station providing a laminar, low velocity isolating air flow.

A further object of the present invention is to utilize offset stabilizing baffles with primary baffles to reduce turbulence and provide a laminar air flow.

Some of the advantages of the present invention over the prior art are that elements of extended length can be cleaned without cross contamination of cleaning liquids, the quantity of cleaning liquid is reduced and the element is not jogged during travel through the system.

Other objects and advantages of the present invention will become apparent from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a broken schematic plan view of a portion of a spray cleaning system according to the present invention.

FIG. **2** is a broken front elevation in section taken along line **2—2** of FIG. **1.**

FIG. **3** is a representation of a typical spray pattern for use with the spray cleaning system of FIG. **1.**

FIG. **4** is a schematic diagram of a spray cleaning system according to the present invention for use in cleaning an aluminum element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A portion of a spray cleaning system **10** according to the present invention is illustrated in FIGS. **1** and **2.** The entire spray cleaning system **10** is housed in an elongated enclosure or tunnel **12** which is open at either end to permit entrance and exit of an element to be cleaned. The spray cleaning system **10** may include as many processing zones or stations as are desirable in accordance with the material characteristics and the physical dimensions of the element to be cleaned; and, of course, the length and physical dimensions of the tunnel **12** are similarly variable in accordance with the element to be cleaned.

It will be appreciated that the portion of the spray cleaning system **10** as shown in FIGS. **1** and **2** is illustrative of cleaning or processing and isolating structure in accordance with the present invention, and such struc-

ture may be utilized wherever such processing and isolating functions are required within the spray cleaning system **10.** A pair of spray stations **14** are aligned with a pneumatic isolating station or air knife **16** in order to define a path of travel **18** therethrough along which the element to be cleaned is moved by any suitable conveying means such as the holders **19** illustrated in FIG. **2.** The holders **19** are operative to support the element to be cleaned such that the element depends therefrom to move freely through tunnel **12** and as many holders **19** may be utilized as are required in accordance with the length and weight of the element to be cleaned. The spray stations **14** and pneumatic isolating stations **16** are structurally symmetrical about the path of travel **18**; and, accordingly, only one side thereof will be specifically described.

Each spray station **14** has, on either side of the path of travel **18** therethrough, a header assembly **24** including a plurality of intermediate headers **26** and a pair of end headers **29** and **31.** Headers **26, 29** and **31** are supported by pillow blocks **28** which are mounted on side walls **30** of the spray stations such that the longitudinal axes of the headers are disposed in parallel spaced relation with intermediate headers **26** positioned between end headers **29** and **31.** Each header **26** has a plurality of spray heads or nozzles **32** in communication therewith and oriented to direct conical sprays **36** of the liquid transversely toward the path of travel **18.** Headers **29** and **31** each have a plurality of flat spray nozzles **33** in communication therewith and oriented to direct flat sheets or curtains **34** of liquid toward the path of travel **18** at an acute angle thereto.

The header assembly **24** for each spray station **14** is serviced by a supply line **38** through which a liquid such as a cleaning fluid or other reagent is pumped from a supply tank (not shown) into a supply manifold **40** which delivers the liquid to inlets **42** for the headers **26, 29** and **31.** The floor in each spray section **14** is constructed of grilled panels **44** such that sprayed liquid may be accumulated in a sump tank **46** located beneath the floor and recycled by means of a pump (not shown) from the sump tank **46** to the supply tank.

Pneumatic isolating station **16** is interconnected between successive spray stations **14** and has a solid floor **48** in order to prevent adverse effects on air flow therein by undesirable pressure gradients developed in the vicinity. On either side of the path of travel **18,** pneumatic isolation station **16** houses vertically stacked baffle assemblies **49** each of which has a front panel **50** with two sets of primary fixed slots or baffles **51** and **52** extending vertically therethrough to divide the front panel into three discrete dampers **53, 54** and **55.** Dampers **53** and **55** have stabilizing baffles or slots **56** and **57** disposed in the outer ends thereof, respectively, which stabilizing baffles are operative to reduce turbulence and provide laminar flow as will be explained hereinafter. An adjustment knob **58** extends from each damper **54** and is interconnected by means of a simple mechanical linkage (not shown) to vanes **60** which are provided in each baffle assembly and are slidable to vary the size of an opening **62** therebetween which leads from a main plenum chamber **64** to provide uniform flow to the baffles. Vanes **60** are adjustable to permit the establishment of a uniform velocity of air through the entire vertical and lateral dimensions of pneumatic isolating station **16.**

A blower (not shown) is operative to pull air from return plenum chambers **66** and **67** disposed on either side of main plenum chamber **64** and force the air through baffle assemblies **49.** Energization of the blower creates an air flow **68** from primary baffles **52** toward an exit **69** of the pneumatic isolating station **16** which air flow **68** is stabilized by a quantity of air **70** supplied through stabilizing baffles **57**; and, similarly, an air flow **70** is directed toward an entrance **71** of pneumatic isolating station **16** from primary baffles **51,** which air flow **70** is stabilized by a quantity of air supplied through stabilizing baffles **56.** The quantity of air supplied by stabilizing baffles **56** and **57** is much less than the quantity of air supplied to the air flow by primary baffles **51** and **52** respectively; and the positioning of the stabilizing baffles between the primary baffles and the exit and entrance of the pneumatic isolating station reduces turbulence and provides laminar air flow.

In operation, the air flow on either side of the pneumatic isolating station **16** and the liquid sprayed on either side of the spray stations **14** will be balanced to prevent jogging of the element being cleaned since jogging is highly undesirable due to the tendency to damage the conveying system and spray system and the difficulty of thoroughly treating the element. That is, jogging of the element causes splashing and unwanted turbulence which prevents the liquids emitted in the spray stations from uniformly contacting the element.

The spray pattern provided on one side of a typical spray station **14** is illustrated in FIG. **3,** and it will be appreciated that the conical sprays **36** provide thorough contact of the liquid with the sides of the element to be cleaned. Flat liquid sheets **34** precisely define the ends of the spray station to effectively provide a curtain at either end of each spray station. That is, as is best illustrated in FIG. **1,** flat sheets **34** emitted from flat spray nozzles **33** on headers **29** and **31** at either end of each spray station contact the element at an acute angle therewith, and each flat sheet **34** is directed away from the pneumatic isolating station adjacent thereto and towards the center of the spray station. That is, headers **29** are disposed adjacent the entrances **71** of pneumatic isolating stations **16,** and the flat liquid sheets **34** from headers **29** are directed away from entrances **71** toward the centers of the spray stations. Similarly, headers **31** are disposed adjacent the exits **69** of pneumatic spray stations **16,** and the flat liquid sheets **34** from headers **31** are directed away from exits **69** toward the centers of the spray stations.

Air flows **68** and **70** in pneumatic isolating stations **16** are initially directed in the same direction as the flat liquid sheets **34** from headers **31** and **29,** respectively. That is, air flow **68** is initially directed toward exit **69** from the center of pneumatic isolating station **16** and extends out to a position adjacent header **31** where it curls back to return plenum chamber **66.** Thus, it will be seen that flat sheets **34** closely cooperate with the air flows in pneumatic isolating station **16**; and, as will be explained hereinafter, this cooperation provides maximum isolation between liquids being sprayed in successive spray stations **14.**

In one specific embodiment, the pneumatic isolating stations **16** are constructed to have a width of approximately four feet which width assures that no high velocity air currents exist. The low velocity laminar air flows **68** and **70** on either side of the pneumatic isolating sta-

tion, which are formed by the cooperation of primary baffles **51** and **52** positioned at 30° from normal with offset stabilizing baffles **56** and **57**, provide a sufficiently large quantity of air to remove from the element the liquid from the preceding spray station and to prevent cross contamination of liquids.

The liquid sprayed in spray stations **14** is emitted with a relatively high velocity forming a thin curtain of liquid on the element as it passes through the spray station. The liquid is sprayed at a flow rate of about one gallon per linear foot of height of the tunnel, and it has been found that at this flow rate the element is thoroughly wetted with liquid once it enters a spray station by the flat liquid sheet **3** from header **31.** Furthermore, once the element has been thoroughly wetted, the flow rate downstream can be substantially reduced without materially affecting the rate of chemical treatment thereby providing great savings in liquid. The downstream flow rate can be as little as one-fourth or even less of the flow rate at the entrance to the spray station. It is desirable to maintain a balanced pressure at all of the nozzles such that all of the nozzles are sprayed at about the same pressure but at different flow rates.

The flat liquid sheets **34** cooperate with the air flows in the pneumatic isolating stations **16** to provide maximum isolation in that they direct or curl the air flows back in a circulation path to the return plenum chambers to aid in the maintenance of low velocity, laminar flow, and flat liquid sheets **34** also prevent drafts from traveling down the tunnel which cause cross contamination of liquids and increase heat losses between spray stations. The localized pressure of the flat liquid sprays is high relative to the pressure of air flows **68** and **70** and the pressure in return plenum chambers **66** and **67** and is believed to be responsible for the excellent isolating results obtained by the use of low velocity, laminar flow therewith.

A complete spray system **10** for use in an aluminum process is illustrated in FIG. **4.** The element to be cleaned is held by a conveyor and moved through the system, and all various processing and isolating stations of the system are desirably maintained continuously in operation although the system can be adapted for sequential operation. The element proceeds through the tunnel and is exposed to the various processing and isolating stations, and an inspection station is provided such that an operator can view the element and make any required adjustments.

It will be appreciated that the combination of the low velocity, laminar air flows from the pneumatic isolating stations and the flat liquid sheets at the ends of the spray stations provide excellent isolation and, further, that the structure of the individual spray stations provides a great savings in treatment liquids. Furthermore, the structure of the pneumatic isolating station is adapted to provide laminar flow which is extremely desirable in the prevention of cross contamination.

Inasmuch as the present invention is subject to many variations, modifications and changes in detail, it is intended that all matter above described or shown in the drawings be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A spray cleaning system for cleaning elements of extended length, said system comprising

a plurality of spaced spray stations successively arranged to define a path of travel for the elements, each of said spray stations including spray means for spraying a liquid on said elements; and

a pneumatic isolating station disposed in said path of travel in the space between each successive pair of said spray stations, each said pneumatic isolating station including baffle means providing a low velocity, laminar isolating air flow directed against the elements only in the space between successive spray stations whereby said liquid sprays in successive ones of said sprays stations are isolated from each other by said air flow.

2. The invention as recited in claim **1** wherein said spray means includes nozzle means disposed adjacent each said pneumatic isolating station to spray a flat sheet of liquid on the elements at an acute angle thereto.

3. The invention as recited in claim **2** wherein said nozzle means is disposed to spray said flat sheet of liquid in a direction away from said pneumatic isolating station and said baffle means is disposed to initially direct said air flow in a direction toward said nozzle means.

4. The invention as recited in claim **3** wherein said baffle means includes primary baffle means supplying a first quantity of air to said air flow and stabilizing baffle means spaced from said primary baffle means and supplying a second quantity of air less than said first quantity of air to said air flow to reduce turbulence and provide laminar flow therein.

5. The invention as recited in claim **4** wherein said stabilizing baffle means is disposed between said primary baffle means and said nozzle means.

6. The invention as recited in claim **2** wherein said nozzle means includes first and second flat spray nozzle means disposed on a first side of said path of travel to provide first and second flat liquid sheets and third and fourth flat spray nozzle means disposed on a second side of said path of travel opposite to said first side to provide third and fourth flat liquid sheets, and said spray means includes a first plurality of spray heads disposed on said first side of said path of travel between said first and second flat spray nozzle means and a second plurality of spray heads disposed on said second side of said path of travel between said third and fourth flat spray nozzle means.

7. The invention as recited in claim **6** wherein said baffle means in each said pneumatic isolating station includes first baffle means disposed on said first side of said path of travel to provide a first isolating air flow adjacent said first flat liquid sheet of one of said spray stations and a second isolating air flow adjacent said second flat liquid sheet of a succeeding one of said spray stations and second baffle means disposed on said second side of said path of travel to provide a third isolating air flow adjacent said third flat liquid sheet of said one spray station and a fourth isolating air flow adjacent said fourth flat liquid sheet of said succeeding spray station.

8. The invention as recited in claim **7** wherein said first baffle means includes first primary baffle means supplying a first quantity of air to said first isolating air flow, first stabilizing baffle means supplying a second quantity of air less than said first quantity of air to said first isolating air flow to reduce turbulence and provide laminar flow therein, second primary baffle means supplying a second quantity of air to said second isolating air flow and second stabilizing baffle means supplying

a fourth quantity of air less than said third quantity of air to said second isolating air flow to reduce turbulence and provide laminar flow therein, and said second baffle means includes third primary baffle means supplying a fifth quantity of air to said third isolating air flow, third stabilizing baffle means supplying a sixth quantity of air less than said fifth quantity of air to said third isolating air flow to reduce turbulence and provide laminar flow therein, fourth primary baffle means supplying a seventh quantity of air to said fourth isolating air flow, and fourth stabilizing baffle means supplying an eighth quantity of air less than seventh quantity of air to said fourth air flow to reduce turbulence and provide laminar flow therein.

9. The invention as recited in claim **8** wherein said first, second, third and fourth flat spray nozzle means are directed away from each said pneumatic isolating station, and said first, second, third and fourth isolating air flows are initially directed toward said first, second, third and fourth flat spray nozzle means, respectively.

10. The invention as recited in claim **9** wherein said first and second spray heads each direct a conical spray transversely toward said path of travel.

11. The invention as recited in claim **1** wherein said baffle means includes primary baffle means supplying a first quantity of air to said air flow and stabilizing baffle means spaced from said primary baffle means and supply a second quantity of air less than said first quantity of air to said air flow to reduce turbulence and provide laminar flow therein.

12. In a continuous spray cleaning system, the combination comprising

a first spray station including first spray means emitting a first liquid;

a second spray station including second spray means emitting a second liquid; and

a pneumatic isolating station having an entrance communicating with said first spray station and an exit communicating with said second spray station, said pneumatic isolating station and said first and second spray stations being aligned to define a path of travel therethrough for an element to be cleaned,

said pneumatic isolating station including first baffle means providing a first low velocity,laminar air flow toward said entrance and second baffle means providing a second low velocity, laminar air flow toward said exit, said first spray means including first flat spray nozzle means disposed adjacent said entrance to said pneumatic isolating station to spray a first flat sheet of said first liquid against an element to be cleaned, and said second spray means including second flat spray nozzle means disposed adjacent said exit of said pneumatic isolating station to spray a second flat sheet of said second liquid against an element to be cleaned whereby said first and second liquids are isolated from each other.

13. The invention as recited in claim **12** wherein said first and second flat spray nozzle means are disposed to direct each of said first and second flat sheets of said first and second flat sheets of said first and second liquids against an element to be cleaned at an acute angle therewith.

14. The invention as recited in claim **13** wherein said first flat sheet of said first liquid is directed away from said entrance of said pneumatic isolating station, said second flat sheet of said second liquid is directed away from said exit of said pneumatic isolating station, said first air flow is initially directed in the same direction as said first flat sheet of said first liquid, and said second air flow is initially directed in the same direction as said second flat sheet of said second liquid.

15. The invention as recited in claim **14** wherein said first baffle means includes first primary baffle means supplying a first quantity of air to said first air flow and first stabilizing baffle means supplying a second quantity of air less than said first quantity to said first air flow to reduce turbulence therein, said second baffle means includes second primary baffle means supplying a third quantity of air to said second air flow and second stabilizing baffle means supplying a fourth quantity of air less than said third quantity to said second air flow to reduce turbulence therein, said first and second primary baffle means are disposed adjacent each other, said first stabilizing baffle means is disposed between said first primary baffle means and said entrance of said pneumatic isolating station, and said second stabilizing baffle means is disposed between said second primary baffle means and said exit of said pneumatic isolating station.

16. The invention as recited in claim **15** wherein said pneumatic isolating station includes a main plenum chamber centrally disposed therein in communication with said first and second primary and stabilizing baffle means, a first return plenum chamber disposed between said entrance and said main plenum chamber and a second return plenum chamber disposed between said exit and said main plenum chamber.

17. The invention as recited in claim **16** wherein said first air flow extends out to a position adjacent said first flat spray nozzle means and curls back to said first return plenum chamber, and said second air flow extends out to a position adjacent said second flat spray nozzle means and curls back to said second return plenum chamber.

18. The invention as recited in claim **17** wherein said first and second spray stations and said pneumatic isolating station are structurally symmetrical about said path of travel therethrough.

19. The invention as recited in claim **1** wherein each said pneumatic isolating station includes return plenum chamber means for said air flow to define a circulation path within the space between successive spray stations.

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