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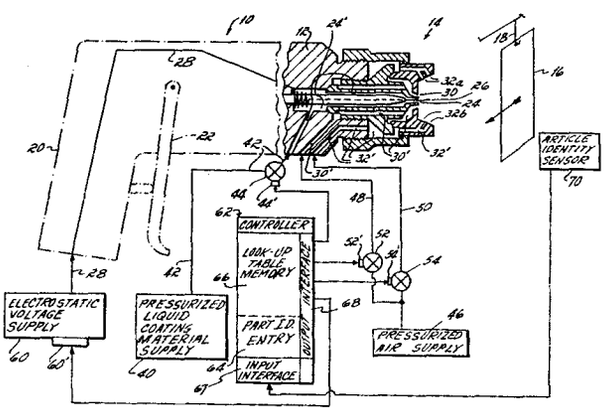
(54) Spray coating apparatus and method.

(57) A spray coating system including a gun from which electrostatically charged liquid coating material, atomized with the aid of a first air stream and shaped in a desired fan pattern with a second air stream, is emitted to coat an object spaced therefrom. Separate signal-controlled valves are provided to independently control the liquid coating flow rate, atomization air stream flow rate, and fan-shaping air stream flow rate. Signalcontrolled electrostatic voltage regulating means are provided to control the magnitude of the electrostatic voltage used to electrostatically charge the liquid coating particles. An electronic controller having means for entering the identity of a particular article to be coated and a «look-up» table memory correlating part identity with the requisite voltage level and flow rates for the coating material, atomizing air stream, and fan-shaping air stream for various articles automatically controls the electrostratic voltage source and the various valves to provide the necessary voltage and flow rates previously empirically determined and stored in the controller memory.



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Spray Coating Apparatus and Method

This invention relates to spray coating systems and more particularly to electrostatic spray coating systems of the type utilizing air to both atomize the electrostatically charged liquid coating material and shape the fan spray pattern thereof.

In certain electrostatic spray coating applications it has been customary to utilize separate air streams to atomize the electrostatically coated particles emitted from the spray gun and shape the fan spray pattern of the emitted particles. In a typical spray gun of this type, a single centrally disposed, generally circular orifice located in the nozzle is provided from which pressurized liquid coating material is emitted in a generally circular fan pattern. An electrode maintained at a preset electrostatic charging voltage projects outwardly from the center of the coating orifice to electrostatically charge the liquid coating as it leaves the orifice. The nozzle of the gun is also provided with a circular array of atomizing air

orifices located concentric with the liquid coating orifice, which impinge the liquid stream issuing from the liquid orifice with air for the purpose of atomizing it. Also located in the nozzle but mounted slightly downstream of the concentrically arranged atomizing air and liquid orifices are two fan spray pattern shaping orifices, which impinge the electrostatically charged and atomized coating particle stream from opposite sides thereof with separate air streams for shaping the circular fan spray pattern into a noncircular shape.

In the past, the atomizing and fan-shaping air streams have been connected to a source of pressurized air through a common air hose in which a single, manually-controlled valve was provided for controlling the air flow rate. By manipulating the single air valve the flow of atomization air and fan-shaping air could be jointly increased or decreased. Control of the coating flow rate in such known systems was provided with a manually-operated valve interconnected between the gun and a pressurized source of paint. Adjustable control of the level of electrostatic charging voltage applied to the electrode in the gun nozzle was provided by suitable manually-operated dial means or the like incorporated in the high voltage electrostatic power supply.

While the prior art system has been found to be satisfactory in many applications, it has found to be unsatisfactory in spraying, at low flow rates, liquid coating material having low solids content. As used herein the term "low flow rate" contemplates flow rates in the range of 40cc-120cc and the term "low solids content" means solids content of 25% or less. In such spraying applications requiring low flow rates of low solids content coating material, the prior art spray systems utilizing a single air valve to jointly control both the atomization air and the fan-shaping air, were unable to adjust the flow rate through the valve such that it would both satisfactorily atomize the coating material and shape the fan pattern. When the single air valve was adjusted to provide an air flow sufficient to fully atomize the liquid coating, the air flow to the fan-shaping orifices was such that instead of converting the circular coating pattern issuing from the coating orifice to an oval pattern, it bisected the oval pattern into two spaced, roughly circular patterns with no coating in the middle region between them. If the air flow was reduced sufficiently with the single valve to avoid bisecting the oval pattern into two separate, roughly circular patterns, the air flow to the atomizing orifice array was insufficient to properly atomize the coating.

Accordingly, it has been an objective of this invention to provide an electrostatic spray gun which utilizes air to both atomize the coating material and shape the fan pattern which can be used to satisfactorily spray low solids content coatings at low flow rates. This objective has been accomplished in accordance with certain principles of this invention by providing separate and independently controlled flow valves between the pressurized air supply and the respective atomizing orifice array and fan-shaping orifice array. In this way the atomizing air and the fan-shaping air can be separately and independently controlled to insure air flow rates to the atomizing and fan-shaping orifices adequate to fully atomize, as well as properly shape, the fan pattern.

In accordance with a preferred embodiment of this invention, the atomizing and fan-shaping flow control valves, the coating material flow control valve, and the high voltage electrostatic supply are signal-controlled from an electronic controller provided with a look-up table memory which correlates for different articles to be coated the requisite combination of charging voltage, coating flow rate, atomization air flow rate, and fan-shaping air flow rate necessary to properly coat each such different article. Upon entry of the identification of the article to be coated into the

electronic controller, such as by a suitable keyboard or the like, the look-up table memory is accessed and the specific combination of charging voltage, coating flow rate, atomization air flow rate, and fan-shaping air flow rate is retrieved. The unique combination of retrieved control parameters for the specific article being coated are applied via a suitable controller output interface, to the high voltage supply, coating valve, atomization air valve, and fan-shaping air valve to achieve the requisite charging voltage, coating flow, and atomization and fan-shaping air flow rates necessary to optimally coat the specific article being sprayed.

These and other advantages, objectives, and features of the invention will be more readily apparent from a detailed description of the preferred embodiment thereof taken in conjunction with the single figure which is a schematic diagram of an electrostatic spray coating system having separate control means for the charging voltage, coating material, atomization air, and fan-shaping air, which are separately controlled from an electronic controller which, in response to entry of the identity of an article to be coated, independently sets the charging voltage, coating flow, and atomizing and fan-shaping air flows to the optimum values.

With reference to the sole figure, the preferred embodiment is seen to include an electro-

static spray gun 10 having a barrel 12 which terminates at its forward end in a nozzle from which electrostatically charged coating particles are emitted in a predetermined pattern toward an article to be coated 16. The article 16, which may be stationary or continuously transported past the spray gun by a conveyor hook or the like 18, is spaced from the spray gun nozzle some predetermined distance which varies depending upon the installation. The spray gun 10 may be provided with a handle 20 if the gun is designed to be manually manipulated by an operator during the spray coating operation in which event the gun is provided with a finger-operated movable trigger 22 for controlling the ON/OFF condition of the spray gun. If the spray gun is designed for use in an automatic installation, the handle and trigger may be omitted and the barrel 12 fastened to a suitable support, movable or stationary, in which event an ON/OFF device for the gun is provided which is under appropriate solenoid control from a program controller or the like.

The nozzle of the gun is provided with a central liquid coating orifice 24 supplied via a suitable passage 24'. Assuming the orifice 24 is circular, liquid coating material when issued from the orifice 24 will be in a generally circular pattern. Axially extending from the liquid coating orifice 24 is an electrostatic coating-charging

electrode 26 supplied from a suitable high voltage cable 28. Surrounding the liquid coating orifice 24 is a concentric circular array of atomization air orifices 30 which are supplied from an atomization air passage 30'. The atomization air orifices 30 impinge with air the liquid coating stream eminating from the orifice 24 for the purpose of atomizing it. Located slightly downstream of the concentrically arranged atomization air orifice array 30 and central liquid coating orifice 24 are a pair of fan-shaping orifices 32a and 32b which are supplied from a passage 32'. The fan-shaping orifices 32a and 32b subject the generally circular pattern of electrostatically charged atomized particles in the region 36 to opposed fan-shaping air jets to transform the generally circular atomized coating pattern to an oval pattern.

To supply controlled flow rates of low solids content coating material to the passage 24', a pressurized source of liquid coating material 40 is provided which is connected to the passage 24' via a hose 42 in which a signal-controlled liquid flow control valve 44 is connected capable of operating at flow rates of 40-120cc/minute. The valve 44, may be of any suitable type, such as is commercially available from Fairchild Industrial Products Division, 1501 Fairchild Drive, Winston-Salem, North Carolina 27105, designated Models

T-5400 or T-5100, coupled with a fluid regulator commercially available from Nordson Corporation, designated Model 246924 or 246794. To supply pressurized air at independently and separately controlled flow rates to passages 30' and 32' a source of pressurized air 46 is provided. Interconnecting the pressurized air source 46 and air passages 30' and 32' are air lines 48 and 50 in which are respectively connected separate signal-controlled air flow valves 52 and 54, respectively. The valves 52 and 54 may be of any suitable type, such as commercially available from Fairchild Industrial Products Division, 1501 Fairchild Drive, Winston-Salem, North Carolina 27105, designated Models T-5400 or T-5100, which are capable of controlling air flow in the range of 1.25-2.0 cfm and 4.0-5.0 cfm for atomization and fan-shaping, respectively.

The valves 44, 52, and 54, which have input control terminals 44', 52', and 54', respectively, are characterized such that as the input signal thereto varies the flow rate therethrough varies. The valves may be responsive to digital control signals or analog control signals, as desired.

The particle-charging electrode 24 is supplied via the high voltage cable 28 from a variable high voltage source 60. The output voltage

of the source 60 is variable in response to a control signal input thereto at control terminal 60', preferably over the approximate range of 60Kv-115 Kv.

To provide the desired combination of control signals to the input terminals 44', 52', and 54' of the valves 44, 52, and 54 and to the input terminal 60' of the high voltage source 60, an electronic controller 62 is provided. Electronic controller 62, which preferably is microprocessor based, includes an article identification entry device 64, such as an alphanumeric keyboard, and a look-up table memory 66, as well as the necessary arithmetic unit, input interface 67, output interface 68, and the like typically found in a microcomputer. For each different article to be sprayed with the gun 10, a different empirically determined unique combination of charging voltage level, coating flow rate, atomization air flow rate, and fan-shaping air flow rate exist to provide optimal coating of the article. The particular charging voltage and coating and atomization and fan-shaping flow rates for various articles is subject to considerable variation depending upon shape of the article, composition of the coating material, distance between the article and the gun nozzle, line speed of the conveyor on which the article is moving past the spray gun, temperature of the coating material,

percentage solids of the coating material, humidity, and the like.

Once the particular combination of charging voltage level, coating flow rate, atomization air flow rate, and fan-shaping air flow rate is determined for a particular article to be coated, the identity of the article is entered into the controller 62 along with the specific charging voltage, and coating and air flow rates. The charging voltage, coating flow rate, and atomization and fan-shaping air flow rates for each particular article are stored in the controller memory in a "look-up" table configuration, such that upon entry into the keyboard 64 of the identification of the article to be coated, the look-up table memory is accessed and the charging voltage, coating flow rate, and atomization and fan-shaping air flow rates for that particular article are retrieved and output from the microcomputer via output innerface 68 to the input terminals 60', 44', 52', and 54' of the high voltage source 60, the paint control valve 44, the atomization air control valve 52, and the fan-shaping air control valve 54, respectively, for adjusting the charging voltage, coating flow rate, atomization air flow rate, and fan-shaping air flow rate, respectively, necessary to optimally coat the particular article.

If desired, an article identification unit 70 can be located along the article conveyor line upstream of the spray gun 10. As articles move past the article identification unit the identity of the articles is automatically determined, using conventional article-identification techniques, and the article identification entered directly into the part identification entry unit 64 of the controller 62 via an input interface 67. In response to entry of the identification of the article, the look-up table memory is accessed and suitable control signals output to the high voltage source 60 and valves 44, 52, and 54. When the article whose identity has been previously sensed reaches the spray gun, the charging voltage and coating flow and air flow rates are automatically set for optimal coating of the particular article whose identity was previously sensed by sensor 70. As different articles are transported past the article identification unit 70 upstream of the gun 10, different article identifications are entered into the article identification entry unit 64 resulting in successive accessing of the look-up table memory 66 and the appropriate combination of control signals successively retrieved and output to the high voltage source 60 and the coating and air flow valves 44, 52, and 54.

An important advantage of this invention attributable to separate and independent control of the atomizing air and fan-shaping air flow rates is that when coating at low flow rates with low solids content coating material sufficiently high atomizing air flow rates can be utilized to assure proper atomization of the coating material without bisecting the oval fan pattern which heretofore resulted when the atomization and fan-shaping flow rates were jointly controlled with a single air flow valve. A further and equally important advantage of this invention, attributable to the use of a controller having a look-up table memory to provide the unique combination of control signals for the high voltage source and the coating and air flow control valves is that the charging voltage and the coating and air flow rates can be automatically adjusted for optimum coating results for a large assortment of different articles.

While the preferred embodiment has been discussed in connection with a coating system which electrostatically charges the coating material to enhance coating ~~a~~ efficiency and wrap, the invention is also useful in non-electrostatic coating systems. An illustrative application where the invention can be used without electrostatically charging the coating

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particles is when coating interior corners of an enclosure. In such applications the electrostatic supply is not used.

What is claimed is:

CLAIMS:

1. Electrostatic spray coating apparatus comprising a spray gun having a nozzle provided with an orifice from which liquid coating material may be emitted, means for supplying pressurized liquid coating material to said orifice, means for impinging liquid coating material emitted from said orifice with pressurized air to atomize the liquid coating material and fan-shaping means for impinging atomized liquid coating material emitted from the nozzle orifice with pressurized air to vary the fan spray pattern of the atomized liquid coating material, characterised in that both a valve to vary the flow rate of atomizing air, and a valve to vary the flow rate of the fan-shaping air are provided, said fan-shaping air valve being controllable independently of the atomizing air valve.

2. Apparatus as claimed in Claim 1 having means to electrostatically change liquid coating material emitted from the nozzle orifice.

3. Apparatus as claimed in Claim 1 or 2 wherein the liquid coating material supply means is such as to supply low solids content liquid coating material to the nozzle orifice at low flow rates for emission therefrom, the said orifice is shaped to emit liquid coating material therefrom in a generally circular pattern, and the atomizing air flow rate valve is controlled to facilitate atomizing low solids content liquid emitted from the orifice at low flow rates, and the fan-shaping air control valve is controlled to

facilitate shaping the said generally circular pattern into a single generally oval pattern.

4. Apparatus as claimed in Claim 2 or 3 wherein the liquid supply means includes a signal-responsive flow control valve to permit selective adjustment of the liquid flow rate therethrough, the said atomizing air control valve and said fan-shaping air control valve are each signal-responsive to permit independent selective adjustment of the respective atomizing and fan-shaping air flow rates therethrough, and the electrostatic charging means is signal-responsive to permit selective adjustment of the electrostatic charging voltage, a controller being provided having:

(a) memory means for storing the identity of different articles to be coated and, for each article, information correlated to its respectively associated unique combination of electrostatic charging potential, liquid flow rate, atomizing air flow rate and fan-shaping air flow rate necessary to optimally coat the article,

(b) means for entering the identity of a specific article to be coated to access the memory means and retrieve information therefrom correlated to the unique combination of electrostatic charging potential liquid flow rate, atomizing air flow rate and fan-shaping air flow rate correlated to the specific article, and

(c) means to apply signals to the electrostatic charging means, liquid valve, atomizing air valve and fan-shaping air valve correlated to the retrieved information for the specific article to

adjust the electrostatic charging potential, liquid flow rate, atomizing air flow rate and fan-shaping air flow rate in accordance with the retrieved unique combination necessary to optimally coat the specific article whose identity was entered into the controller.

5. Apparatus as claimed in Claim 4 including, article transport means for conveying different articles in operative relation to the spray gun, article sensing means for sensing the identity of the conveyed articles, and wherein the identity-entering means is responsive to the article sensing means to facilitate automatic entry into the controller of the identity of articles conveyed past the spray gun.

6. A method of electrostatically coating an article with liquid, comprising the steps of, supplying pressurized liquid to a spray gun having a liquid orifice from which liquid is emitted, electrostatically charging the emitted liquid, simultaneously impinging the emitted liquid with separate pressurized atomizing and fan-shaping air streams to simultaneously atomize and shape the fan pattern of the emitted liquid, and independently adjusting the air flow rates of the atomizing and fan-shaping air streams to optimize spray coating of an article being coated.

7. A method of electrostatically coating an article with low solids content liquid at low flow rate, comprising the steps of, supplying, at low flow rate, low solids content liquid to a spray gun having a liquid orifice from which liquid is emitted in a

generally circular pattern, electrostatically charging said emitted liquid, impinging a first pressurized air stream against said emitted liquid to produce atomization thereof, impinging a second pressurized air stream against said atomized liquid to shape the fan spray pattern, and independently adjusting the atomizing and fan spray pattern shaping air flow rates to optimally atomize said liquid and shape said spray pattern into a single oval-shaped pattern.

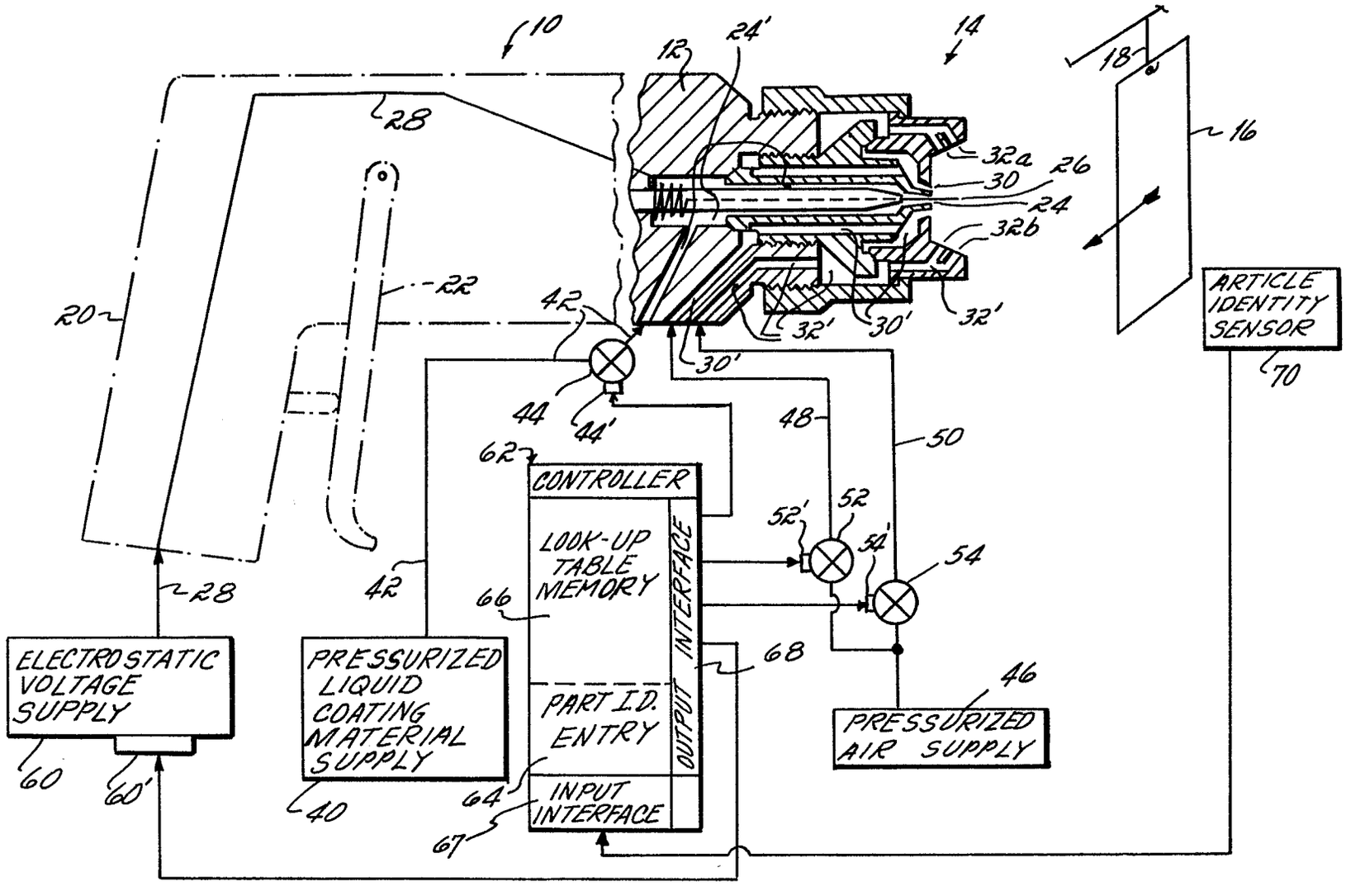
8. A method of electrostatically coating an article with liquid, comprising the steps of, supplying pressurized liquid to a spray gun orifice from which liquid is emitted via a signal-responsive liquid flow control valve, electrostatically charging said emitted liquid from an electrostatic supply having signal-responsive means for controlling the electrostatic charging voltage, supplying a pressurized atomizing air stream to a gun atomizing orifice via a first signal-responsive air flow control valve, supplying a pressurized fan-shaping air stream to a gun fan-shaping orifice via a second signal-responsive air flow control valve, storing in the memory of a controller in correlation with the identity of different articles to be coated information related to different unique combinations of electrostatic charging voltage, liquid flow rate, atomizing air flow rate and fan-shaping air flow rate necessary to optimally coat said different articles, entering into the controller the identity of a specific article to be coated and in response thereto

accessing a memory to retrieve information therefrom correlated to the unique combination of liquid flow rate, atomizing air flow rate, fan-shaping air flow rate, and electrostatic charging voltage necessary to optimally coat said specific article, and applying to said signal-responsive means of said electrostatic supply, liquid valve, atomizing air valve, and fan-shaping air valve signals correlated to the unique combination of electrostatic charging voltage, liquid flow rate, atomizing air flow rate and fan-shaping air flow rate information retrieved from said memory in response to the entry into the controller of the identity of said specific article.

9. The method of Claim 8 further including the steps of, conveying different articles in operative relation to said spray gun, sensing the identity of conveyed articles prior to reaching the spray gun, and inputting the sensed identity of conveyed articles into the controller to facilitate automatic entry into the controller of the identity of articles conveyed past the spray gun.

10. A method of electrostatically coating an article with low solids content liquid at low flow rate, comprising the steps of, supplying, at low flow rate, low solids content liquid to a spray gun having a liquid orifice from which liquid is emitted in a generally circular pattern, impinging a first pressurized air stream against said emitted liquid to produce atomization thereof, impinging a second pressurized air stream against said atomized liquid

to shape the fan spray pattern, and independently adjusting the atomizing and fan spray pattern shaping air flow rates to optimally atomize said liquid and shape said spray pattern into a single oval-shaped pattern.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32a
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32b
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42
32'
30'
32'
ARTICLE IDENTITY SENSOR
70
44
44'
30'
48
50
62
CONTROLLER
LOOK-UP TABLE MEMORY
OUTPUT INTERFACE
52'
52
54'
54
66
68
46
PART I.D. ENTRY
INPUT INTERFACE
64
67
ELECTROSTATIC VOLTAGE SUPPLY
PRESSURIZED LIQUID COATING MATERIAL SUPPLY
PRESSURIZED AIR SUPPLY
60
60'
40
28
42

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