

United States Patent [19]

Cowan

[11] 3,843,052

[45] Oct. 22, 1974

[54] PNEUMATICALLY ASSISTED HYDRAULIC
SPRAY COATING APPARATUS

[75] Inventor: Philip L. Cowan, Morris Plains, N.J.

[73] Assignee: Electrogasdynamics, Inc., Hanover,
N.J.

[22] Filed: Dec. 21, 1972

[21] Appl. No.: 317,207

Related U.S. Application Data

[63] Continuation of Ser. No. 120,444, March 3, 1971,
abandoned.[52] U.S. Cl. 239/3, 239/15, 239/296,
310/11

[51] Int. Cl. B05b 5/00

[58] Field of Search 239/3, 15, 296; 310/5,
310/6, 11

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Primary Examiner—Lloyd L. King

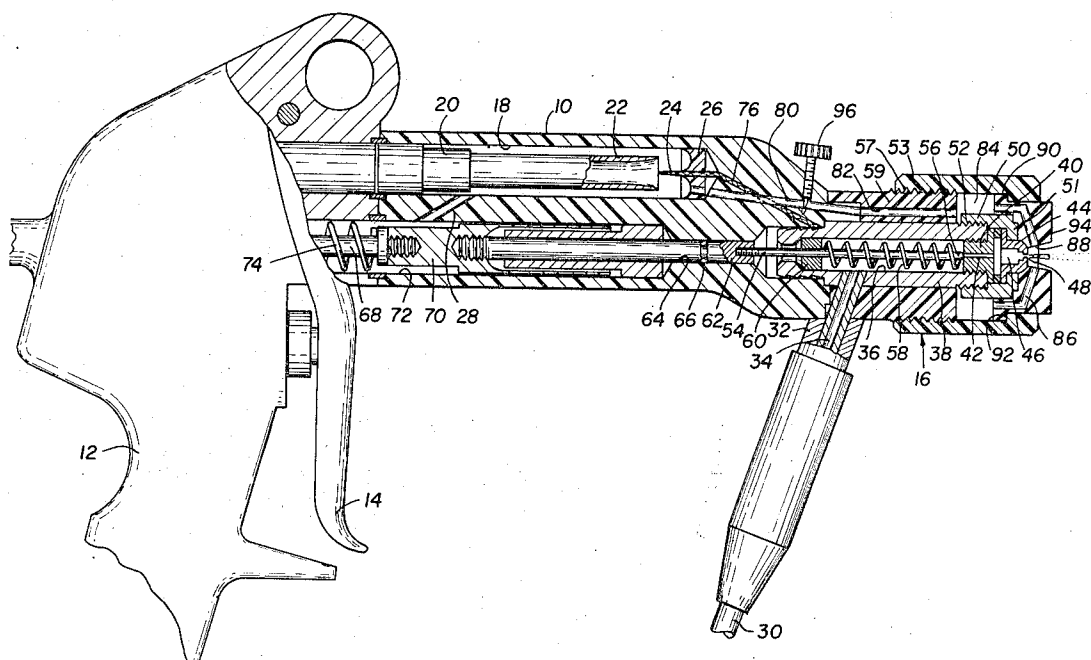
Assistant Examiner—Michael Y. Mar

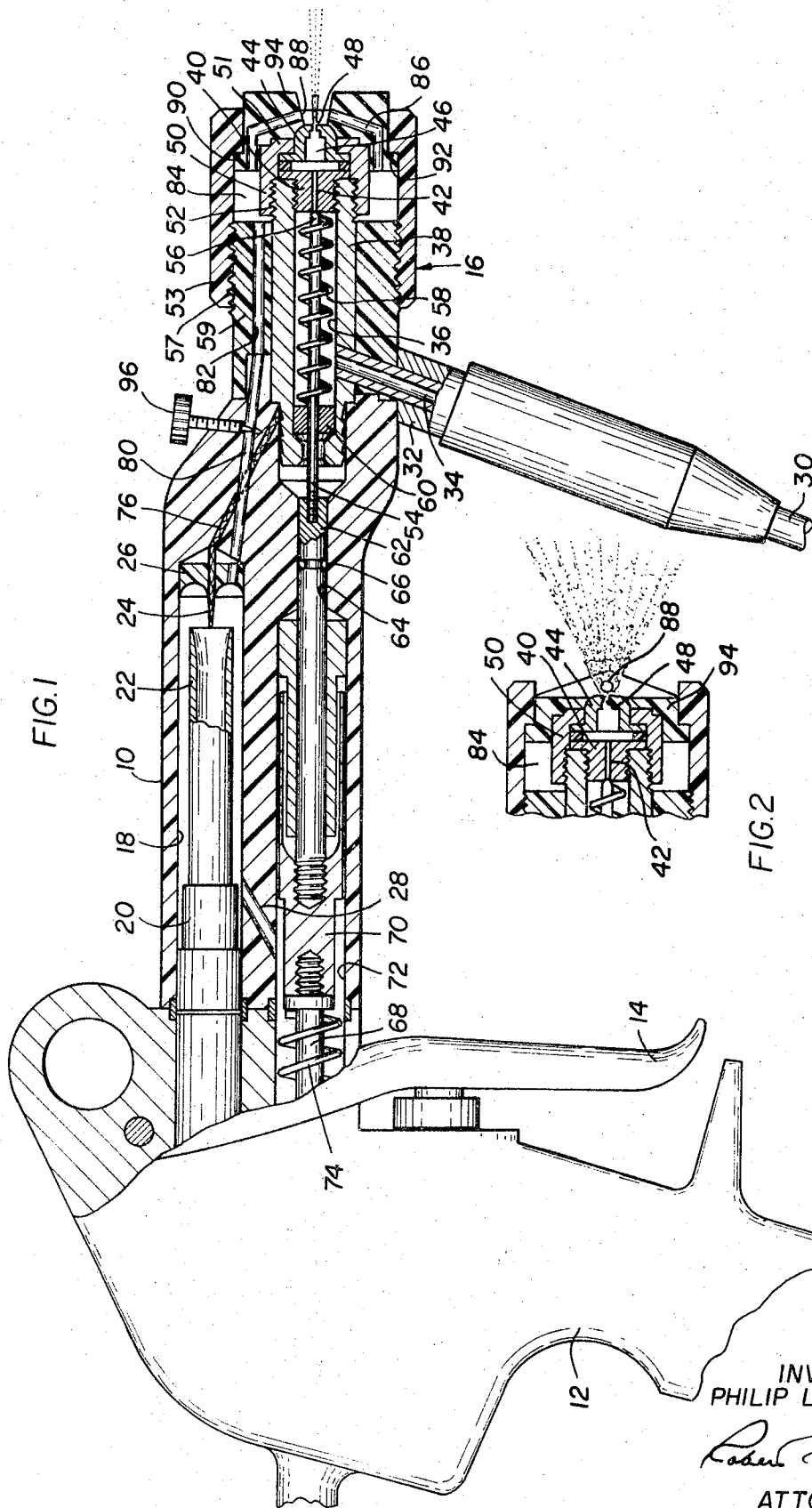
Attorney, Agent, or Firm—Robert E. Isner

[57] ABSTRACT

A pneumatically assisted hydraulic atomizing apparatus for paint or other liquids. The spraying apparatus includes an atomizing head assembly which has a selectively shaped orifice for transforming coating liquid such as paint, into a high speed expanding coherent flat and fan shaped film of such liquid that inherently develops unstable wavelike characteristics leading to the atomization of the emitted liquid at the front edge of the film in combination with means for directing gaseous jets into impinging relation over substantially the full transverse extent of the coherent fan shaped film to decrease the thickness thereof and accelerate the atomization whereby the fluid emission velocity for a predetermined degree of atomization can be substantially reduced.

11 Claims, 2 Drawing Figures





INVENTOR
PHILIP L. COWAN

Robert E. Cowan
ATTORNEY

PNEUMATICALLY ASSISTED HYDRAULIC SPRAY COATING APPARATUS

This is a continuation of Ser. No. 120,444, filed Mar. 3, 1971, now abandoned.

This invention relates to the hydraulic atomization of liquids and more particularly to an improved method and apparatus for effecting a pneumatically assisted hydraulic or "airless" atomization of coating materials.

Hydraulic or "airless" atomization of paint has been in commercial use for approximately 20 years and has gained wide acceptance in the spray-coating industry. In such "airless" type systems, and particularly those in which the liquid is emitted in the form of a flat, coherent fan shaped film 1, the atomization of the coating material, for example paint, is effected by hydraulic means and is conventionally achieved either by delivering the liquid paint under a high hydrostatic pressure (up to 3,000 psi) to a small selectively shaped orifice to thereby force the liquid through the orifice at a high velocity to form a high speed flat fan shaped film or by impacting the liquid in the form of a high velocity-low pressure submerged jet against a selectively shaped orifice of a fluid nozzle. In both of these basic hydraulic atomization techniques, atomization is effected by the development of instabilities in the high speed fan shaped liquid film.

Both of the above described systems however are subject to inherent operational difficulties which are a continuous source of inconvenience and unwarranted expense to the operator. In general the fluid nozzle assemblies and the aperture defining portions thereof must be made of very hard material such as tungsten carbide and are not only expensive to fabricate but are subject to relatively rapid wear due to the abrasive nature of the high velocity liquid streams of coating material passing therethrough. The fluid orifices of these nozzles are usually very small in size (typically equivalent in area to a circular orifice of about 0.013 inches) and are thereby inherently subject to spray distortion, if not cessation of flow, by the clogging presence of very small amounts of particulate material in the coating liquid. Extreme care must be exercised in filtering the liquid if undue amounts of down time and consequent production stoppage that is required to clean such spray orifices is to be avoided. Additionally, the shape of the emitted coherent film of liquid is largely dependent upon the shape of the orifice and accordingly the fluid nozzle must be changed when it is desired to alter or modify the shape of the fan.

In conventional "airless" spray coating systems of the type described above, neither the pressure nor the velocity of the liquid stream can be reduced significantly, since to do so lengthens the emitted expanding coherent film and increases the size of the atomized liquid droplets producing generally poorer atomization.

In spite of the inherent operational difficulties experienced with "airless" painting systems of the type described, these systems have gained wide acceptance because of their unique and beneficial spraying characteristics. The absence of the large codirectional air flows characteristic of air atomization systems results in greatly reduced overspray and bounce back of the coating material, particularly on large flat workpieces, with a consequent high efficiency utilization of coating material. Additionally the large volumes of air mixed with flammable paint and solvent vapor which must be

conducted away from the area in which the paint is being applied by hoods, stacks and the like that are characteristic of air atomization systems is avoided and the attendant problems are thereby materially reduced.

This invention may be briefly described as an improved method and apparatus for hydraulically inducing the emission of coating liquid through an orifice in the form of a thin, flat coherent fan shaped film that is continuously converted into an atomized spray at its forward edge and directing gaseous jets into impinging relation with the opposed surfaces of the fan shaped film to modify the shape and thickness of the film and to accelerate the atomization thereof but without substantially reducing the amount of the required hydraulically supplied atomizing energy. In its narrower aspects the subject invention includes utilization of a portion of the air passing through an electrogasdynamic power generator that is adjunctively employed to maintain an electrostatically induced ionized atmosphere and an associated electrostatic depositing field, for such pneumatic assistance.

Among the advantages of the subject invention is a permitted increase in the size of the liquid emitting orifices in hydraulic atomizing apparatus with a concomitant reduction in the problems of spray distortion and clogging that have heretofore been characteristic thereof; and a permitted marked reduction in the velocity of the coating liquid passing through the emitting orifice with a consequent reduction in the detrimental abrasive effects thereof and an increase in the life of the associated pumping mechanism through operations at reduced pressures. Still further advantages include an increase in the uniformity of atomization across the spray pattern and the avoidance of use of a small diameter pre-orifice of the type described in U.S. Pat. No. 3,000,576 when operating at low pressure and thereby eliminating the need to match the orifice with the fluid nozzle. A still further advantage of the present invention is the provision of electrostatic spray coating system in which the inherent advantages of airless atomization techniques are combined with a lower forward speed of the charged spray than heretofore possible resulting in markedly increased deposition efficiency.

The object of this invention is the provision of methods and apparatus for pneumatically assisting the formation of hydraulically atomized spray coatings.

Other objects and advantages of the present invention will become apparent from the following portion of this specification and from the accompanying drawings which illustrate, in accord with the mandates of the patent statutes, a presently preferred embodiment incorporating the principles of the invention.

Referring to the drawings:

FIG. 1 is a side elevational view partially in cross-section, of an "airless" hand spray gun, of the electrostatic type, constructed in accordance with the teachings of the present invention.

FIG. 2 is a fragmentary horizontal sectional view of the front end portion of the "airless" hand spray gun illustrated in FIG. 1.

Referring to the drawings and initially to FIG. 1, a hand spray gun of the so-called "airless" type is provided which is of the electrostatic type and has incorporated therein an electrogasdynamic high voltage generator as an integral power source therefor. The particular construction illustrated effects atomization of the

paint or other coating fluid by one of the two techniques heretofore described i.e., by impacting a submerged high speed low pressure fluid jet on a small selectively shaped orifice preferably in the form of a double crescent or "cats eye" to form an expanding coherent flat fan-shaped film of fluid which disintegrates into droplets at its forward edge, as disclosed in U.S. Pat. No. 3,000,576, referred to earlier.

In more particularity, the illustrated hand gun includes a selectively configured insulating barrel portion 10 having a pistol grip type of conducting handle portion 12, a fluid release actuating trigger 14 mounted at one end thereof and an atomizing nozzle and charging assembly, generally designated 16, at the other end thereof.

The upper portion of the insulating barrel 10 contains a first relatively large elongated bore 18 which is adapted to removably receive an electrogasdynamic power generator assembly, generally designated 20, in which the electric power necessary to charge the atomized paint spray particles and to create the electrostatic depositing field is derived from the direct conversion of the kinetic energy of the moving stream of air containing a small amount of condensable "seed" material, suitably alcohol, therein, that passes therethrough. Such operating air, which is conveniently introduced and vented through the bottom of the handle 12, is injected under pressure, in response to the actuation of the trigger 14 into the electrogasdynamic power generator. The flow velocity of the seeded air is markedly increased, preferably so as to be in the vicinity of sonic velocity when it is discharged into the elongated generator channel 22 as a stream containing electrically charged particles. After exiting from the generator channel 22, the air stream impinges against the adjacent axially disposed collector needle electrode 24, which is mounted in a plug 26, and expands into the barrel bore 18 flowing therewithin at reduced velocities toward the generator exit conduit 28.

Suitable liquid coating material, such as paint, is introduced into the atomizing nozzle assembly 16 of the gun through a paint supply line 30 connected to a suitable fitting 32 disposed on the underside of the barrel portion 10 and containing an inlet duct 34 of electrically conducting material. The liquid inlet duct 34 is in direct fluid communication with the bore 36 of a generally cylindrically shaped sleeve member 38 mounted in the forward end of the barrel 10. Sleeve member 38 is formed of conducting material and the bore 36 thereof serves as a temporary coating liquid reservoir or chamber. Threadedly mounted to the forward end of the sleeve member 38 is a conducting valve block 40 which has a longitudinal bore 42. Positioned forwardly of the valve block 40 is a liquid nozzle 44. As shown, valve block bore 42 opens into an enlarged bore or chamber 46 defined within the liquid nozzle that forwardly terminates in a selectively contoured orifice 48 that controls the shape of the emitted liquid preferably in the form of a coherent flat fan shaped film which disintegrates at its forward edge and is atomized into a spray of discrete droplets. The general area within which the emitted coherent liquid film is converted into a spray of discrete droplets may conveniently be defined herein as the "locus of atomization" and generally extends no more than one quarter to one half inch from the nozzle orifice.

The forward end 51 of the retaining nut 50 is cylindrical in form so as to properly locate the liquid nozzle 44 with liquid nozzle chamber 46 positioned in longitudinally aligned and compressively assembled relation with the valve block bore 42 when threadedly secured as at 52 to the forward end of the sleeve member 38.

Flow of liquid coating material through the above described nozzle assembly is controlled by a valve rod 54 which is displaceable within the bore 36 and whose forward end 56 is normally biased by a spring 74 into sealing relation with a valve seating surface of the valve block 40 at the entry to the valve block 42. The valve rod 54 extends rearwardly through a spring loaded packing gland 60 which is mounted at the rear of the sleeve bore 36 and is terminally connected to a connecting rod 62 of insulating material slidably disposed within a second bore 64 in the barrel portion 10 of the gun. A second liquid seal element, suitably an O-ring 66, is included to minimize, if not preclude, coating liquid leakage at the interface of the rod 62 and the second barrel bore 64. The rearward end of the rod 62 is connected to actuating rod element 68 which forms a component of the trigger assembly through an intermediate insulating coupling element 70 slidably disposed within a third enlarged bore 72 within the barrel portion 10 and coaxial with the second barrel bore 64.

In the operation of the above described elements, actuation of the trigger 14 results in a conjoint retractive displacement of the rod 68, coupling 70, connecting rod 62 and valve rod 54 against the action of the biasing spring 74 and in an opening of the valve block bore 42. The high pressure liquid in the bore 36 flows outwardly through the valve block bore 42 and is accelerated into a small diameter high velocity, low pressure liquid jet. This small diameter, high velocity, low pressure liquid jet passes in submerged condition through the coating liquid accumulated in the nozzle chamber 46 and impacts against the defining surface of the nozzle orifice 48 with a portion thereof passing therethrough. As previously pointed out, the orifice 48 is preferably contoured to effect the emission of the coating liquid as a coherent and generally, flat, fan shaped film, which, is converted into a spray of discrete droplets of coating material short distance downstream from the orifice.

For the illustrated electrostatic type unit, the inlet duct 34, sleeve member 38, valve block 40, valve rod 54, and retaining nut 50 are all desirably formed of suitable electrically conducting metal and are adapted to be charged to a high electrical potential, preferably negative, through the conductor 76 embedded in the insulating barrel 10 of the gun and connected to the high voltage output or collector electrode 24 of the electrogasdynamic generator 20. Because of the high potential applied to the nozzle assembly components, the forward end of the gun includes an insulating cap member 53 which is threadedly mounted, as at 57, to the barrel extension member 59, also formed of insulating material. The insulating cap member 53 serves to shroud the charged nozzle assembly components at the forward end of the gun.

As noted above, the passage of the stream of seeded air through the electrogasdynamic power generator 20 results in the generation of high d.c. voltages at the collector electrode 24 and in the direct application thereof, through the conductive elements 76, 38, 40 to

the metallic nozzle tip member 44, which thereby performs the function of serving as the charging electrode for the electrostatic deposition system. The application of such potentials to the fluid tip nozzle member 44 will create a corona discharge condition adjacent the terminus thereof and an area rich in unipolar ions closely adjacent to the locus of atomization, which ions attach themselves to and selectively charge the atomized paint particles, and. In addition, if the coating material is conductive, the coating material droplets will receive an electric charge by contact as they break free of the fan shaped film. Under such conditions the fluid tip nozzle member 44, which is charged in the manner described, will also serve as one terminus of an electrostatic depositing field with the other terminus thereof being constituted by the grounded object to be coated.

In accord with the principles of this invention and to secure a permitted marked reduction in the required delivery pressure and velocity of the liquid jet of paint or the like whereby nozzle wear can be reduced and film distortion and orifice clogging due to particulate matter being entrained within the liquid jet can be minimized, an auxiliary jet of gas is directed to impinge against the coherent expanding film intermediate its point of emission and the locus of atomization thereof.

In the illustrated embodiment, a small portion of the seeded operating air exhausting from the generator 20 is desirably diverted from the first barrel bore 18 and passed through a conduit compositely defined by barrel air assist bore 80, the barrel extension air assist bore 82, and into an annular cavity 84 in the nozzle assembly.

Such air is conveniently discharged from said cavity 84 through a pair of diametrically disposed bores 86 in the air cap member and through the exit apertures 88 therein in the form of gas jets into impinging relation against the coherent fan shaped film of emerging liquid. Such gas jets are preferably directed against the flat faces of the fan shaped film although some operation can be effected by directing assisting jets against the marginal side edges of the expanding film to limit the expansion thereof.

When directed against the opposing planar surfaces of the hydraulically formed coherent liquid film, the gas jets effect a lateral broadening of the film with a consequent curvature in the defining side edges of the fan, increase in the contained angle thereof and a decrease in the thickness. As a result of such action, the locus of atomization is caused to move closer to the fluid orifice and the uniformity across the pattern is improved.

It has been found that with the introduction of auxiliary air jets, as shown, a reduction by a factor of two or more in the required operating pressure of the liquid jet is readily attainable, while still maintaining the same effective degree of atomization. With such reduction in liquid jet pressure, the nozzle orifice 38 size can be significantly increased and wear thereon decreased.

As noted above, the auxiliary air jets when directed against the opposed planar surfaces of the film tend to additionally flatten the expanding coherent film. Accordingly a control valve 96 is provided to regulate the amount of operating air diverted from the generator exhaust stream and redirected to the air assist conduit whereby a degree of control over the shape of the li-

uid fan can be exercised. The amount of air so redirected is sufficiently small so as not to appreciably create the well known air blast effects of air atomizing guns and operation thereof accordingly is not characterized by significant amounts of "bounce back" of paint from the work being coated. Additionally since the liquid velocity markedly is reduced the efficiency of the spray-coating apparatus will be increased, especially in electrostatic spraying, since fewer liquid droplets will overcome the electrostatic depositing field forces.

Although a wide range of operation is possible, operation in accordance with the principles of this invention are effected when the quantity of assist gas employed in the fan engaging jets would be insufficient to effect atomization of the liquid in the absence of the hydraulic force inducing liquid emission. Likewise operation is preferably effected when the emission velocity of the coating liquid would be insufficient to effect acceptable atomization thereof in the absence of the gaseous assist jets.

It has also been found experimentally that the use of auxiliary air jets which emerge parallel to the faces of the fan shaped film and impinge on the thin edges result in generally improved atomization of the spray. The use of such jets result generally in a decrease in the spray pattern width and an indexing head in which the jets can be oriented either normal to or parallel to the fan faces provides a large measure of control over the spray shape.

Having thus described my invention, what I claim is:

1. An apparatus for spray-coating an article comprising a liquid atomizing head including a selectively shaped orifice for transforming coating liquid delivered thereto into a thin high velocity expanding coherent and essentially planar flattened fan shaped liquid film which is atomizable into a spray at its forward edge independent of interaction of high velocity air therewith, means for delivering liquid to said selectively shaped orifice for said film forming emission there-through and means for directing auxiliary gaseous jets into impinging relation against the essentially planar defining surfaces of said high velocity expanding coherent fan shaped liquid film to modify the locus of atomization thereof.
2. An apparatus for spray coating an article according to claim 1, wherein said liquid delivering means includes means for impacting a submerged jet of such liquid against said selectively shaped orifice at low pressure and high velocity.
3. An apparatus for spray coating an article according to claim 1 wherein said gaseous jets operatively impinge against the emitted liquid adjacent the point of emission thereof.
4. An apparatus for spray coating an article according to claim 1 wherein said gaseous jets operatively impinge against the emitted liquid at a location closer to the point of emission thereof than the locus of atomization thereof in the absence of such gas jets.
5. An apparatus for spray coating an article according to claim 1 including means for electrostatically charging said atomized liquid particles and for maintaining an electrostatic depositing field therefor.

6. An apparatus for spray coating an article according to claim 1 further comprising valve means for regulating the flow of gas directed against the opposing sides of the film to control the dispersal pattern of the atomized material.

7. In a method of electrostatically depositing a coating material on an article wherein liquid coating material is hydraulically emitted as a coherent flat fan shaped spray that progressively forms an atomized spray into an electrostatic depositing field in proximity to an electrostatically induced ionized atmosphere, the step of passing air delivered from a remote supply thereof through an electrogasdynamic power generator to maintain said electrostatically induced ionized atmosphere and said depositing field at an average field strength of a magnitude proportional to the rate of flow of said air and diverting a portion of said air into direct impinging engagement with the opposite surfaces of said fan shaped film to accelerate the atomization thereof.

8. The method as set forth in claim 7 wherein the quantity of air employed in said diverted portions of air is insufficient to effect atomization of said liquid in the absence of said hydraulic forces inducing emission thereof.

9. The method as set forth in claim 7 wherein the velocity of emission of said coating liquid would be insufficient to effect atomization thereof in the absence of said diverted portion of air.

10. An apparatus for spray-coating an article comprising

a liquid atomizing head including a selectively shaped orifice for transforming coating liquid delivered thereto into a high velocity thin expanding coherent

ent and essentially planar flattened fan shaped film which is atomizable into a spray at its forward edge independent of interaction of high velocity air therewith,

means for delivering liquid to said selectively shaped orifice for said film forming emission therethrough and

means for directing auxiliary gaseous jets into impinging relation against the marginal side edges of expanding and essentially planar coherent fan shaped film of liquid to modify the spray pattern thereof.

11. An apparatus for spray-coating an article comprising

a liquid atomizing head including a selectively shaped orifice for transforming liquid delivered thereto into a thin high velocity expanding coherent flattened fan shaped film which atomizes at its forward edge,

means for delivering liquid to said selectively shaped orifice for emission therethrough,

means for directing gaseous jets into impinging relation against the opposing planar surfaces of the high velocity expanding coherent fan shaped film of liquid,

means for electrostatically charging said atomized liquid particles and for maintaining an electrostatic depositing field therefor,

electrogasdynamic power generating means disposed within said apparatus operatively responsive to a flow of seeded air there-through and

means for diverting a portion of such seeded air to form said gaseous jets.

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