

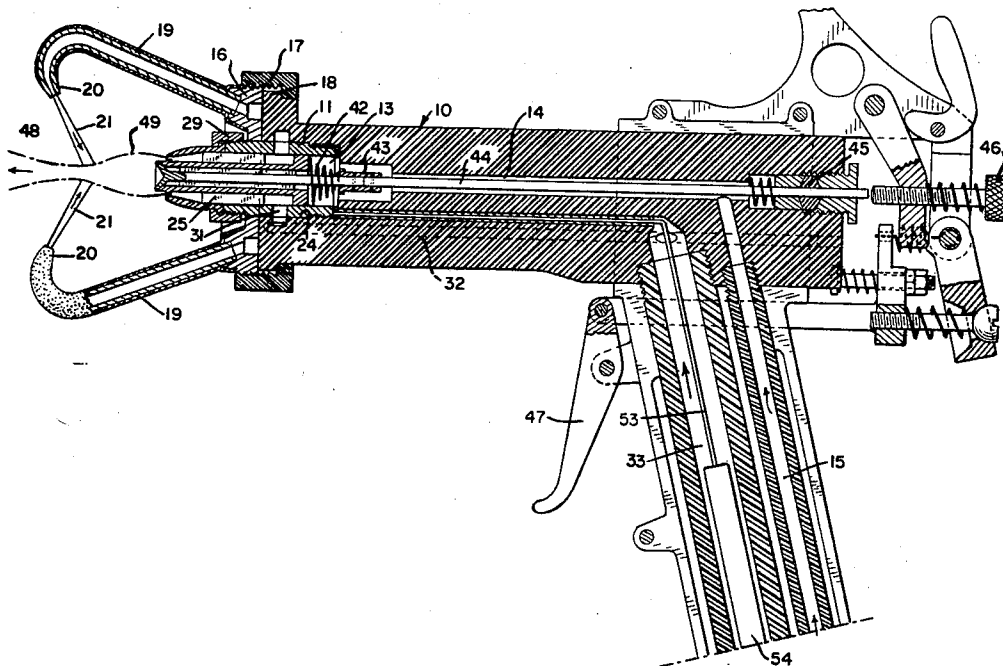
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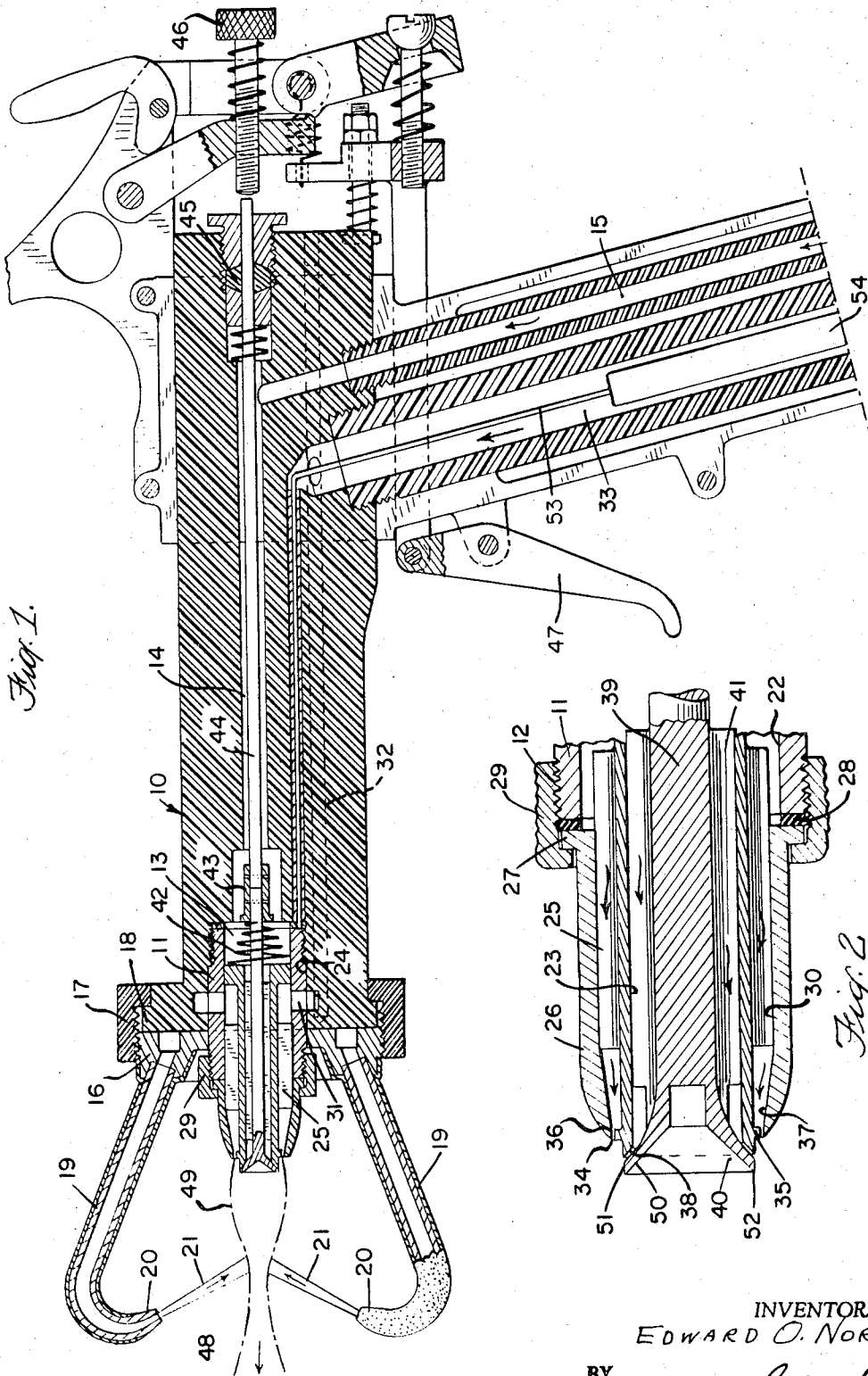
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[54] **ELECTROSTATIC AIR-LIQUID ATOMIZING**
NOZZLE FOR PAINTS AND THE LIKE
8 Claims, 2 Drawing Figs.

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239/290, 239/416.4, 239/417.3
[51] Int. Cl..... **E01b 5/00**
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413, 407, 415, 416, 417, 290, 291, 292

ABSTRACT: The invention is directed to air-liquid atomizing nozzles, particularly for electrostatic paint spray systems. The nozzle of the invention is characterized by having an annular liquid discharge opening closely surrounded by an annular air discharge opening. The arrangement of the air discharge opening is such that the air, while being discharged in a generally cylindrical flow, is caused and permitted immediately to contract in diameter in front of the nozzle, and thereafter to gradually expand in diameter to form a desired paint spray pattern.





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ELECTROSTATIC AIR-LIQUID ATOMIZING NOZZLE FOR PAINTS AND THE LIKE

RELATED APPLICATIONS

The present application is a continuation-in-part of my earlier application Ser. No. 340,466, filed Jan. 27, 1964, now U.S. Pat. No. 3,344,922, and of my application Ser. No. 443,736, filed Feb. 19, 1965, now abandoned. The last mentioned application was a division of my earlier application Ser. No. 85,312, filed Feb. 27, 1961, now abandoned. The nozzle construction of the present invention is useful to particular advantage in the overall environments of the parent applications, while not necessarily being limited thereto.

BACKGROUND AND PRIOR ART

Air-liquid atomizing nozzles tend to fall predominantly into two major classes: nozzles for atomizing fuel for combustion, and nozzles for the application of coating materials, such as paint. Although there necessarily are similarities in the nozzle constructions of these major classifications, there are important distinctions in the objectives and in the desired operating characteristics, from which derive significant distinctions in the optimum structural configurations of the nozzles. In the design of fuel atomizing nozzles, for example, principal objectives are fine atomization of the fuel and thorough mixture of the fuel with air, for uniform, high efficiency combustion. In a painting nozzle, it is also desirable, of course, to achieve fine, uniform atomization of the paint or other coating material. However, rather than achieve maximum exposure of the liquid material to the surrounding air, it is desired (and achieved with the apparatus of the invention) to relatively confine and control the configuration of the spray pattern, to achieve high efficiency deposition of the coating material on the surfaces to be coated and avoid excessive losses of coating material as mist in the air. Particularly where the atomized spray of coating material is to be shaped or modified, as by air jets or additional, convergently related spray streams, proper confinement of the atomized stream of coating material is especially desirable and important.

Additional important design considerations which are applicable to the construction of air-paint nozzles are the reliable avoidance of accumulated droplets of paint in the discharge end area of the nozzle, and in the preferred provision of advantageous facilities for imparting an electrostatic charge to the atomized droplets of coating liquid. As will be readily understood, if a paint atomizing nozzle is permitted to accumulate droplets of the coating material, which occasionally become detached and are conveyed to the surface of the work, the work will be spoiled. With fuel burning nozzles, in contrast, while it is a general objective to achieve fine, uniform atomization, the occasional accumulation and release of larger droplets is a matter of no concern. Likewise, provisions for electrostatic deposition form no part of the design of fuel burning nozzles, and no accommodation need be made in the design of such nozzles for the charging of the atomized particles.

In accordance with one aspect of the present invention, an air-paint atomizing nozzle is provided, which includes a valved, annular paint discharge opening of substantial diameter which is surrounded by an annular air discharge opening. The air discharge opening is of large diameter in relation to its width, so as to effect the high velocity discharge of air in a forward, generally cylindrical pattern over and about the annular paint discharge opening. The construction of the forward end extremity of the nozzle is such that the parts of the nozzle that are surrounded by the annular air discharge opening and extend forward therefrom are equal or smaller in diameter than the inner diametral dimension of the air discharge opening. This arrangement is such as to prevent any outward flaring of the cylindrical air stream, as by the presence of any deflecting surface on the forward extremity of the nozzle. In addition, it is particularly advantageous to provide, at the end extremity

of the air discharge opening a constriction formed by a radially outwardly projecting annular rib. The constriction provides efficient, high velocity emission of the air stream and, in addition, provides that the inside diametral dimension of the cylindrical air stream, at the point of issuance is somewhat greater than the diameter of any portion of the nozzle which is surrounded by the air stream and is located forwardly of the issuance point.

Another advantageous feature of the invention resides in the provision, in an air-paint atomizing nozzle of the type contemplated, of a controllably reciprocating paint valve element for opening and closing the paint supply. The valve base has an enlarged head which, when opened, defines the annular paint discharge opening. The paint valve head, in accordance with the invention, is provided with a sharply angled, typically conical recess in its forward face, which extends radially to the outermost extremities of the valve head. The provision of a recess in this form accomplishes two important objectives: First, it provides for the total absence of a flat surface area on the front of the valve head, such that the deposition of paint droplets on the front of the valve head is reliably precluded. Second, there is at the same time formed a forwardly facing annular sharp edge, which can be utilized for efficiently charging the atomized paint particles as desired for electrostatic paint spraying techniques.

The spray nozzle of the invention, by causing a controlled convergence of the atomized paint stream, followed by a gradual divergence thereof, is particularly suitable for the application of spray coating materials, because the spray pattern is accurately confined to a spray pattern of reasonable size. In spray painting, for example, if the atomized spray is issued in a widely diverging cone, it is more difficult to obtain overall coating without undue waste. Further, the nozzle of the invention is particularly desirable in the environments of the parent applications, where the issued streams of atomized paint are modified as to shape and velocity prior to deposition of the spray material. In the environment of my prior application Ser. No. 443,736, for example, the sprays of a pair of nozzles are converged, in a manner such that each of the sprays modifies the shape and velocity of the other to form a desired, combined low velocity spray. The closely confined configuration of the spray stream is importantly advantageous in achieving optimum interaction between the converging spray streams. In the environment of my parent application Ser. No. 340,466, the issuing spray stream is acted upon, modified and retarded by reentrant, opposed streams of air, and this is most advantageously effected by directing the reentrant air jets in the convergent region of the atomized spray pattern.

For a better understanding of the invention, reference should be made to the accompanying drawings and to the following description of a preferred embodiment of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal cross-sectional view of an air-paint spray gun apparatus incorporating the improved nozzle construction of the invention.

FIG. 2 is an enlarged, fragmentary cross-sectional view showing details of the nozzle structure incorporated in the spray gun of FIG. 1.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawing, the reference numeral 10 designates a spray gun body, which is formed of a suitable nonconductive structural plastic material. Adjacent its forward end, the gun body 10 is recessed for the reception and threaded engagement of a nozzle sleeve 11. The nozzle sleeve has a portion projecting forward of the front extremity of the gun body 10, terminating in a threaded portion 12. The inner end of the sleeve 11 communicates, through a recess 13, with passages 14, 15, through which paint or other spray coating material is supplied for atomization, as will be described.

In the illustrated form of the invention, other aspects of which are described in more detail in my copending application Ser. No. 340,466, an annular element 16, descriptively referred to as a horn ring, is received over the projecting forward end of the sleeve 11 and sealed against the front face of the gun body 10. The inner end of the horn ring is threaded to receive a clamping ring 17, which is engaged by a flange 18 on the forward end of the body 10. A pair of air jet horns 19 extend forward from the horn ring 16 but have their discharge ends 20 directed inward and rearward for the discharge of reentrantly directed air jets 21 toward the principal discharge axis of the spray gun, as will appear.

Received within the cylindrical inner wall 22 of the nozzle sleeve 11 is an elongated nozzle tube 23. The nozzle tube is held in fixed position, relative to the sleeve 11, and is provided with an outwardly flanged inner end 24 arranged to form a seal with the cylindrical sleeve surface 22. Spaced forward of the flange 24 are a series of longitudinally disposed, radially projecting ribs 25, arranged to engage the cylindrical inner surface 22 of the sleeve 11 to support the nozzle tube 23 precisely in concentric relation with the sleeve. The ribs 25 project beyond the forward extremity of the nozzle sleeve 11 for the reception and precise concentric support of a nozzle ring 26.

As shown particularly in FIG. 2, the nozzle ring 26 is provided with a radially flanged inner end 27, which seats against the forward face of the sleeve 11, advantageously through a sealing ring 28, and is firmly secured to the sleeve by means of a threaded clamping ring 29. By the provision of relatively close tolerance fitting between the ribs 25 of the nozzle tube 23 and a cylindrical inner wall 30 of the nozzle ring 26, precise concentricity may be maintained between the nozzle tube and ring at the discharge end of the nozzle.

In the nozzle assembly of the invention, the generally annular passage formed between the nozzle tube and ring elements 23, 26 constitutes an air passage, advantageously communicating through radial passages 31 in the sleeve 11 with air supply passages 32, 33 in the gun body and handle. The annular air chamber thus provided in the nozzle may be of relatively large cross-sectional dimensions, to accommodate the relatively unrestricted forward flow of air toward the discharge end of the nozzle. However, in accordance with the invention, the nozzle ring and tube are arranged to provide an air discharge opening of a substantially constricted nature, and having a width which is a small fraction of the diameter of the annular opening. Typically and advantageously, a nozzle according to the invention may have an annular air discharge opening of approximately three-eighths inch diameter, for example, with the width of the opening being on the order of 5 to 10 mils.

As one of the specific features of the invention, the air discharge opening, designated by the reference numeral 34, is formed in part by a radially outwardly projecting annular rib 35 provided with a short, cylindrical outer surface forming one wall of the discharge opening. In a typical nozzle assembly, the rib 35 may have a height, measured radially, of about 5 mils. The other wall of the discharge opening is a cylindrical surface portion 36 of the nozzle ring 26.

Advantageously, the cylindrical surface 36 is of somewhat smaller diameter than the principal inner surface 30 of the nozzle ring, being connected thereto by a frustoconical surface 37. As will be understood, the axially forward flow of air through the nozzle assembly is relatively unrestricted, except immediately at the discharge opening, where the air is discharged at high velocity through the highly constricted opening formed between the opposed cylindrical surfaces of the nozzle ring 26 and the annular rib 35.

As is particularly evident in FIG. 2, all portions of the nozzle structure, including a valve element to be described, which are located forwardly of the annular air discharge opening 34 are advantageously of smaller diameter than the inner diametral dimension of the annular stream of discharging air, as determined primarily by the diameter of the annular rib 35. As a

limiting condition, the inner portions of the nozzle structure, which lie forward of the air discharge opening, might approach a diameter equal to that of the inside of the discharge annular air stream, but more advantageously, these forward inner portions of the nozzle structure are of somewhat lesser diameter. This enables the inner stream, initially discharged in a cylindrical configuration, to project forward and beyond the forward end extremities of the nozzle structure free of any outward deflecting forces or surfaces. The arrangement is such that the initially cylindrical stream of high velocity air is caused to converge to a smaller diameter, at a region directly in front of the nozzle, before again expanding. The typical flow configuration, substantially as indicated in FIG. 1, may involve a slight initial enlargement of the stream, which presumably results from the initial expansion and deceleration of the air. Immediately thereafter, the stream contracts.

Advantageously, the nozzle tube 23 extends a short distance (e.g., about 30 mils, in a typical nozzle) forward from the annular rib 35, where it terminates in a frustoconical surface 38 forming a valve seat. A valve element 39, having an enlarged valve head 40 is arranged for longitudinal opening and closing movements within the nozzle tube 23 and has a valve surface arranged to seat lightly against the surface 38 when the valve is closed. As shown in FIG. 2, the valve element 39 is provided with a plurality of longitudinally disposed, radially directed ribs 41, engaging the inner cylindrical wall of the nozzle tube 23 to support and guide the valve element 39 in concentric relation to the nozzle tube while providing an axial passage for the flow of paint or other coating material toward the valve head. Normally, the valve element 39 is urged into a fully closed position, by means of a spring 42, which bears against the inner end of the nozzle tube 23 and against a coupling element 43 secured to the inner end of the valve stem. A valve actuating rod 44, formed of insulating material, extends through the liquid passage 14 and through a packing 45, and extends outward at the rear of the gun body for engagement by a control element 46. Actuation of the control element 46 is under the selective control of the gun operator, through a suitable linkage ultimately connected to a control trigger 47. The control arrangement, which is described in more detail in my copending application Ser. No. 340,466, enables the paint valve element 39 to be opened and closed, as well as adjusted, under the manual control of an operator, or under suitable remotely actuated control arrangements, as will be understood.

As shown in FIG. 2, the diameter of the valve head 40 at its forward extremity is the same as the outside diameter of the forward extremity of the nozzle tube 23, so as not to provide a surface which would tend to deflect outwardly the flow configuration of the air stream.

When the valve element 39 is opened, as by a slight forward movement of the actuating rod 44, to form a narrow conical discharge opening at the valve seat 38, the coating liquid, which is typically an appropriate paint-solvent mixture, is caused or permitted to have a more or less oozing flow forward to the outer extremity of the valve head 40. At this point, the oozing liquid is picked up by the cylindrical air stream, flowing at a much higher velocity, causing the liquid to be finely atomized and carried forward with the air stream.

In accordance with the invention, the forwardly moving stream of air and atomized liquid converges to a zone of minimum diameter, a short distance in front of the nozzle, substantially as indicated at 48 in FIG. 1, typically after first slightly enlarging in diameter in the zone indicated at 49 in FIG. 1. After passing the zone of convergence, the atomized spray stream then expands until ultimately the stream contacts the object to be coated or is otherwise dissipated.

Of particular advantage, the spray stream configuration achieved by the nozzle structure of the invention is at all times relatively confined and controlled, and of relatively narrow angle, as in distinct contrast to the more typical spray configurations in which the spray material fans out widely immediately upon leaving the discharge end of the nozzle. With the spray

stream configuration achieved pursuant to the invention, it is possible to converge a pair of spray streams to great advantage, substantially as reflected in my prior U.S. Pat. No. 3,301,488, and it is also possible to modify and decelerate the spray stream to great advantage in the manner of my copending application Ser. No. 340,466. Even without modification and/or shaping and/or decelerating of the spray stream, however, the spray configuration achieved in accordance with the invention has important advantages by reason of the relatively close confinement of the spray stream at substantial distances forward of the end of the nozzle, which greatly increases spray deposition efficiencies, particularly where penetration into recesses is desired.

In accordance with one of the specific aspects of the invention, the valve head 40 is provided at its forward end extremity with a deep, sharply angled recess 50 which expands to the outermost extremity of the valve head, as defined by the outer cylindrical surfaces 51 thereof. Thus, in the illustrated arrangement, the recess 50 is of generally conical configuration, having an included angle on the order of 90 degrees. The arrangement is such that the valve head 40 has effectively no frontal surface area in the region of the forward extremities of the valve head. This is particularly advantageous in connection with spray painting equipment because the valve head 40 presents no front surface area for the accumulation of droplets of the liquid paint. Ideally, all of the liquid paint should be finely atomized and carried forward for deposition on the work pieces. However, practical experience indicates that, when using a paint discharge opening of annular form and of substantial diameter, there tends to be an accumulation of droplets on the front face of the valve. When this occurs, large droplets are carried off of the valve head from time to time and deposited upon the work to form an obvious defect. In accordance with the invention, however, by limiting the front surface area of the valve head to a sharp annular edge at the forwardmost and outermost extremity of the valve head, the formation of droplets is reliably avoided.

A further specific feature of the invention resides in the forming of the valve head 40 to have a forwardly facing, as distinguished from a radially facing, sharp edge which may be charged with an electric potential to impart an electrostatic charge to the atomized particles of liquid coating material. As particularly illustrated in FIG. 2, the conical surface of the recess 50 meets with the cylindrical outer surface 51 of the valve head at its forwardmost and outermost extremity to define the desired forwardly facing sharp edge 52. The valve element 39, being formed of conductive material, may be appropriately connected to a high potential source through a conductor 53 and resistor 54 to impart the desired charge to the valve head area. Thus, the particular valve head configuration illustrated in FIG. 2 serves not only to prevent droplet accumulation on the valve head, but also improves the electrostatic charging of the spray particles by reason of the formation of the generally forwardly facing sharp outer edge 52.

The specifically illustrated apparatus, in typical operation is provided with a steady supply of air to the nozzle, through air passages 31-33, so that there is a steady stream of high velocity air issued from the gun, more or less in a pattern indicated at 48, 49 in FIG. 1. As described in more detail in my copending application Ser. No. 340,466, spray operations are initiated by actuating the control trigger 47, simultaneously to actuate the valve element 39 from its closed position, illustrated in FIG. 1, to its open position, illustrated in FIG. 2, and to open the air connections to the reentrant jet nozzles 20. Liquid, oozing through the narrow conical opening between the valve seat 38 and valve head 40, is picked up by the high velocity air stream, finely atomized and carried forward in a spray pattern that first slightly enlarges, then contracts significantly and then expands gradually as it progresses toward the work piece.

Most advantageously, as explained in my copending application Ser. No. 340,466, the reentrant jets 20 are directed at the stream of atomized paint, generally in the zone of con-

tracted diameter, where maximum effectiveness and control is achieved in shaping and decelerating the spray stream.

When the control trigger 47 is released, the valve element 39 closes off the conical paint discharge opening, and residual paint is atomized and carried away by the air stream, which continues to flow. The closed valve head 40 prevents clogging of the paint discharge area and enables the equipment to be restarted without special cleanup or the like.

It should be particularly noted that the initial discharge of the high velocity annular air stream from the air discharge outlet 34 is substantially parallel to the axis of the nozzle, in a cylindrical air stream configuration, notwithstanding the convergent inner surface 37 at the outer end of the nozzle ring 26 and the rather abrupt outward projection of the annular rib 35. In this respect, it is the configuration of the constricted discharge passage which is the controlling influence, and this passage is defined by opposed cylindrical surfaces which are parallel to the nozzle axis.

The nozzle construction of the invention represents a significant advance in the art, by reason of the close confinement of the discharged stream of atomized coating material. While this is particularly advantageous in connection with the use of modified and/or decelerated spray streams, and also in connection with the use of electrostatic paint spray techniques, it is also of important advantage in connection with paint spray procedures which do not incorporate modification or charging of the spray. In this respect, it is of particular advantage to provide a relatively closely confined spray stream, so that the spray coverage is confined to a practical area of the work.

It should be understood that the specific form of invention herein illustrated and described is intended to be representative only, as certain changes may be made therein without departing from the clear teachings of the disclosure. Accordingly, reference should be made to the following appended claims in determining the full scope of the invention.

I claim:

1. An atomizing nozzle for air and coating liquid, which comprises:

- a. a nozzle tube;
- b. a nozzle ring surrounding said nozzle tube and forming therewith an air passage for the forward flow of air under pressure;
- c. air supply means connected to said air passage;
- d. opposed and cooperating surface means on said nozzle ring and tube forming an annular air discharge opening;
- e. said opposed and cooperating surface means comprising concentric, cylindrical surface portions of the nozzle tube and nozzle ring coaxial with the longitudinal axis of the nozzle tube;
- f. said air discharge opening being of very large diameter in relation to the width of the opening and constituting a constriction relative to the air supply passage, to enable the discharge at high velocity of a circular air stream;
- g. said nozzle tube terminating at its forward end in an annular valve seat;
- h. a valve element slidably received within said nozzle tube and having an enlarged valve head arranged to close against said valve seat;
- i. said valve head and valve seat being controllably slidable to open and closed positions and defining, when in an open position, an annular liquid discharge opening;
- j. coating liquid supply means connected to said nozzle tube;
- k. said air supply means and said coating liquid supply means being so related to each other and to their respective discharge openings that the air is discharged at a significantly higher velocity than the coating liquid; and
- l. all portions of the nozzle which are located forward of the effective forward terminus of said nozzle ring and are contained within the envelope of the discharged circular air stream, being contained within a cylindrical envelope coaxial with the nozzle tube and of a diameter not greater than the effective outside diametral dimension of the nozzle.

zle tube at the transverse plane of said effective forward terminus.

2. The atomizing nozzle of claim 1, further characterized by:

- a. said valve head having a deep recess in its forward face;
- b. said recess having divergent walls extending forward and outward to the outer extremities of the valve head; and
- c. said valve head thus being substantially completely free of flat frontal surface area in the region of its outer extremities.

3. The atomizing nozzle of claim 1, further characterized by:

- a. said air supply passage being of substantially larger flow passage area than said air discharge opening;
- b. said nozzle ring having a first cylindrical wall of an enlarged diameter, a second cylindrical wall of a reduced diameter forming the outer wall of the air discharge opening, and a converging wall joining said first and second cylindrical walls; and
- c. said nozzle tube having an annular portion of increased diameter having a cylindrical outer wall facing the second cylindrical wall of said nozzle ring and forming therewith a constricted air discharge opening.

4. The atomizing nozzle of claim 1, further characterized by:

- a. said nozzle tube having a radially projecting annular rib forming part of said annular air discharge opening; and
- b. said valve seat and valve head being located forward of said air discharge opening, a distance which is slightly greater than the distance of radial projection of said rib.

5. An atomizing nozzle for air and coating liquid, which comprises:

- a. a nozzle tube;
- b. a nozzle ring surrounding said nozzle tube and forming therewith an air supply passage for the forward flow of air under pressure;
- c. opposed and cooperating surface means on said nozzle ring and tube forming an annular air discharge opening;
- d. said air discharge opening being of very large diameter in relation to the width of the opening and constituting a constriction relative to the air supply passage, to enable the discharge at high velocity of a circular air stream;
- e. said nozzle tube terminating at its forward end in an annular valve seat;
- f. a valve element slidably received within said nozzle tube and having an enlarged valve head arranged to close against said valve seat;
- g. said valve head and valve seat being controllably slidable to open and closed positions and defining, when in an open position, an annular liquid discharge opening;
- h. all portions of the nozzle located forward of said air discharge opening and contained within the envelope of the discharged air stream being of equal or smaller diameter than the inner diametral dimension of the air discharge opening;
- i. said nozzle tube having an annular, radially outwardly

projecting rib adjacent its forward end; and

- j. said rib having a cylindrical outer surface forming the inner surface of the air discharge opening.

6. The atomizing nozzle of claim 5, further characterized by:

- a. said nozzle tube having an extension projecting forward from said annular rib and terminating in said valve seat;
- b. said valve head and said extension being of diameters, which are less than the outer diameter of said annular rib; and
- c. the diameter of said extension being at least as large as the diameter of said valve head.

7. An atomizing nozzle for air and coating liquid, which comprises:

- a. a nozzle tube;
- b. a nozzle ring surrounding said nozzle tube and forming therewith an air supply passage for the forward flow of air under pressure;
- c. opposed and cooperating surface means on said nozzle ring and tube forming an annular air discharge opening;
- d. said air discharge opening being of very large diameter in relation to the width of the opening and constituting a constriction relative to the air supply passage, to enable the discharge at high velocity of a circular air stream;
- e. said nozzle tube terminating at its forward end in an annular valve seat;
- f. a valve element slidably received within said nozzle tube and having an enlarged valve head arranged to close against said valve seat;
- g. said valve head and valve seat being controllably slidable to open and closed positions and defining, when in an open position, an annular liquid discharge opening;
- h. all portions of the nozzle located forward of said air discharge opening and contained within the envelope of the discharged air stream being of equal or smaller diameter than the inner diametral dimension of the air discharge opening;
- i. said valve head having a generally cylindrical outer surface;
- j. the front surface portion of said valve head having a forwardly divergent surface extending outward into intersecting relation with said cylindrical outer surface;
- k. said intersecting surfaces forming a forwardly facing, sharp annular edge over which air and liquid are caused to flow; and
- l. said valve head being formed of electrically conductive material and being connectable to a source of electric charging potential.

8. The atomizing nozzle of claim 7, further characterized by:

- a. said forwardly divergent surface extending rearward for a substantial distance to form a deep recess in the front of said valve head; and
- b. the frontal surface area of said valve head, in the region of the cylindrical outer surface thereof, consisting exclusively of said sharp annular edge.