Dec. 27, 1955 W. L. SMART ET AL 2,728,606

LIQUID FEEDING APPARATUS

Filed May 24, 1954 2 Sheets-Sheet 1

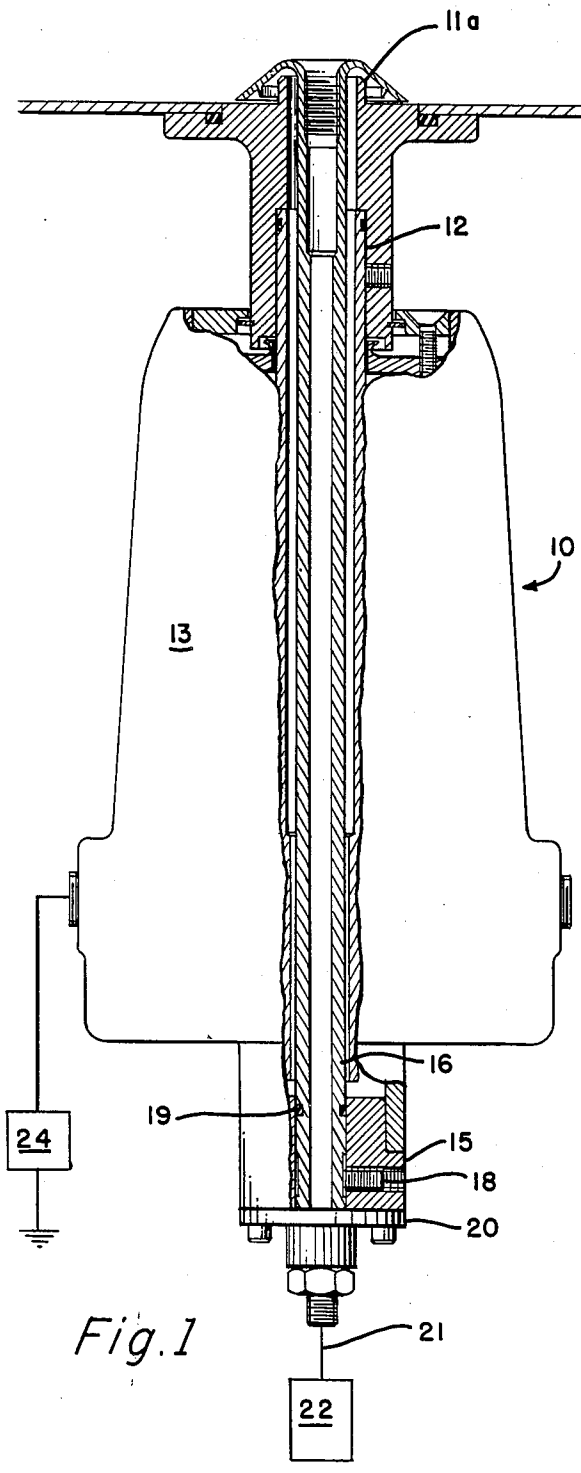


Fig. 1

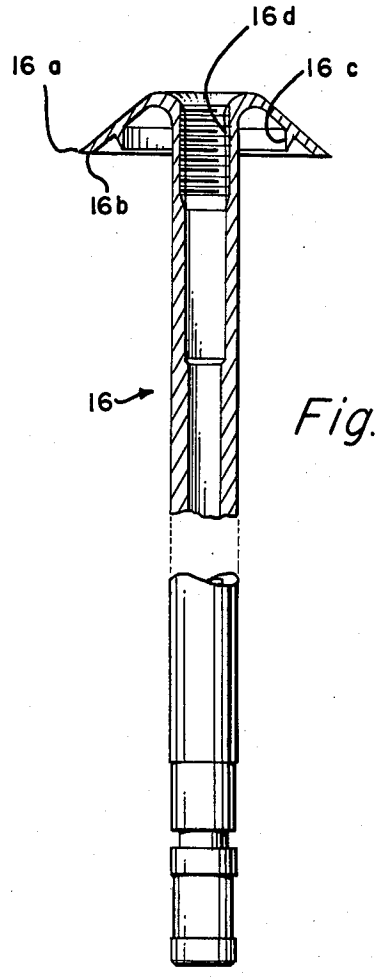


Fig. 2

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LIQUID FEEDING APPARATUS

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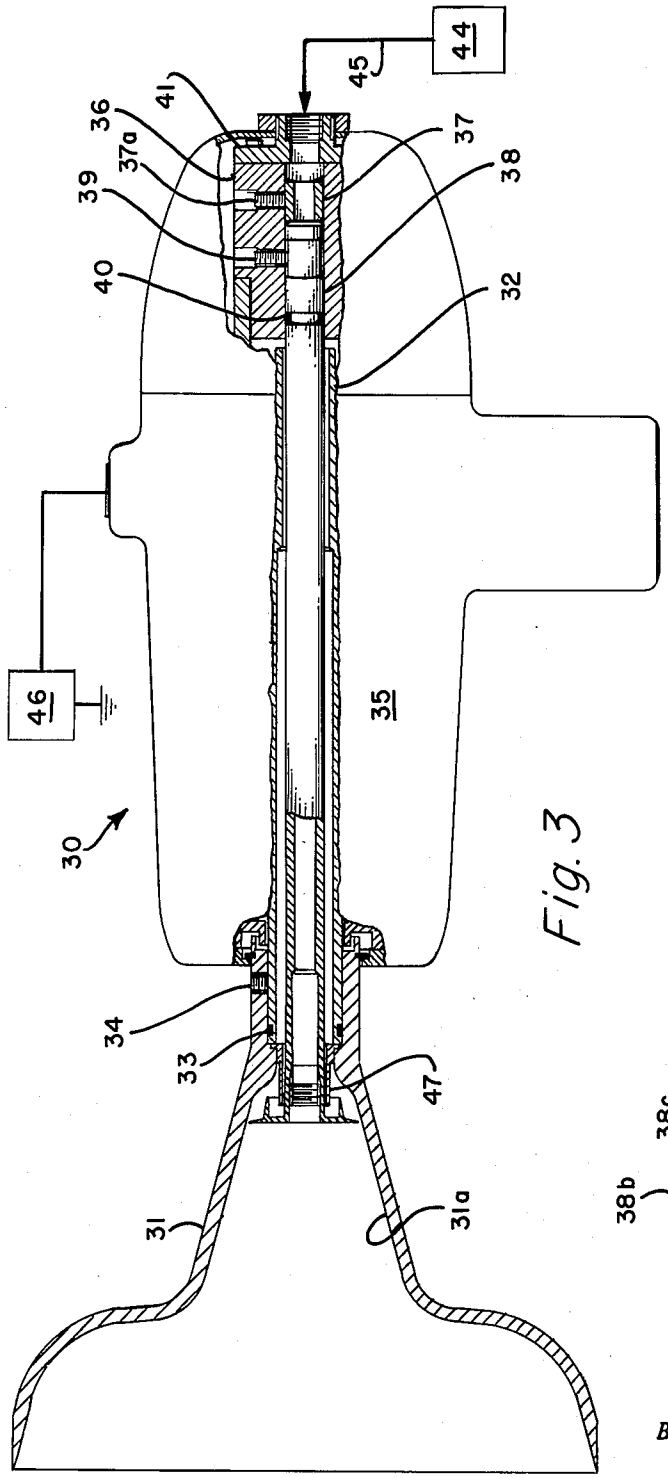


Fig. 3

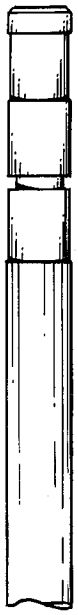
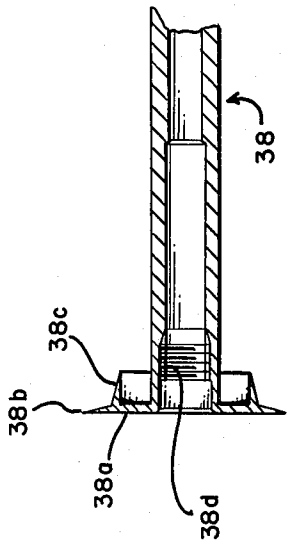


Fig. 4



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LIQUID FEEDING APPARATUS

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Application May 24, 1954, Serial No. 431,768

12 Claims. (Cl. 299—63)

Our invention relates to apparatus for feeding liquid from a stationary means to a rotating means, particularly for feeding liquid coating material from a stationary feed tube to a rotating atomizing device.

Numerous industrial processes require that a liquid be fed from a stationary member to a moving member without appreciable loss or leakage of the liquid from its desired path of flow. For example, in the electrostatic spray coating of articles of manufacture it has been found particularly desirable to feed liquid coating material from a stationary reservoir to a rotating atomizing device such as a flat disc or flaring bell for atomization therefrom and electrostatic deposition on the articles. Where the atomizing device is being used to spray in a generally horizontal or an upwardly direction, proper feeding of the liquid coating material to the rotating device has presented a number of problems.

It is well known that certain liquid coating materials, particularly some pigmented paints, have extremely abrasive qualities and that on exposure to air most liquid coating materials leave a gummy residue. Moreover, liquid coating materials generally contain solvents which readily attack the materials used in conventional liquid sealing devices. These qualities make the useful life of conventional sealing devices very short. Once the liquid coating material leaks past its seal, its abrasive and gummy qualities will quickly render the bearing structure and other moving parts of the rotating atomizing device unserviceable. It is therefore desirable in feeding liquid coating material to such a device that conventional mechanical seals and related packings be eliminated and that steps be taken to insure that liquid coating material does not reach the bearing structure.

The problem of feeding liquid coating material to a rotating atomizing device is further complicated by the fact that a very steady, laminar flow is required. Spurting and other forms of turbulence in the transfer of the liquid from the stationary member to the rotating member tends to produce "slugging"; that is, turbulence in the liquid transfer often causes droplets or "slugs" of liquid which are too large for commercial spray coating to be discharged from the rotating atomizing device and deposited on the articles being coated. Slugging may ruin the appearance of the coated article and necessitate its rejection and complete refinishing. This, of course, is costly and to be avoided.

Our invention is directed to providing means for feeding liquid from a stationary to a rotating member in a steady, laminar flow and without the use of conventional packings or liquid sealing devices. We have discovered an efficient liquid feeding device for use in an electrostatic coating system or the like which comprises a rotatable hollow shaft and an annular-edged atomizing device mounted for rotation on one end of the shaft having an extended liquid-guiding surface which leads to the atomizer's annular atomizing edge. A stationary feed device generally in the form of a tube extends through the shaft terminating in an annular liquid discharge edge of

knife-like sharpness which is closely and equally spaced from the liquid-guiding surface of the atomizer. Preferably the discharge edge is spaced not more than .05 inch from the liquid-guiding surface. When the shaft and atomizer are rotated and liquid is fed at a controlled rate through the stationary feed tube the liquid will flow without turbulence through the tube and over its liquid discharge edge to the liquid-guiding surface of the rotating atomizer to form an expanding liquid film for atomization from the edge of the atomizer.

An object of our invention is to provide improvements in a rotary liquid utilization device for the protection of the bearing structure and other movable parts of the device. Another object is to provide a more efficient means for feeding liquid coating material and the like generally upwardly or horizontally to a rotating atomizing device.

Means for accomplishing the above stated and related objects of our invention will now be described in detail with reference to the accompanying drawings in which:

Fig. 1 is a partially broken away elevational view of one type of atomizing device embodying a form of our invention;

Fig. 2 is a detailed view of the stationary feed tube shown in Fig. 1;

Fig. 3 is a partially broken away elevational view of a second type of atomizing device utilizing another embodiment of our invention; and

Fig. 4 is a detailed view of the stationary feed tube shown in Fig. 3.

Our invention is particularly adapted for use in feeding liquid coating material to a rotating atomizer used in an electrostatic coating system. The invention may, however, assume many forms and for convenience of illustration there are shown in the drawings and will now be fully described two specific embodiments of our invention in an electrostatic coating system which are illustrative of the principles of the invention. The scope of the invention, however, is not to be limited by the following description.

Referring first to Figs. 1 and 2 there is shown an annular-edged atomizing device **10** which includes an atomizing disc and hub assembly (hereinafter called a disc) **11** on the upper end of a rotatable hollow shaft **12**. The disc and shaft are rotated by an integral motor assembly lying within a housing **13** whose details are not shown as our invention is independent of the motor or other driving means for shaft **12** and disc **11**.

Shaft **12** extends axially through housing **13**. Beneath the lower end of rotatable shaft **12** and affixed to housing **13** is a stationary tube support **15** having an axial passageway concentric with shaft **12** and disc **11**. A stationary feed device or tube **16** is securely mounted concentrically within the passageway of stationary tube support **15** by means of a set screw **18** and sealed by an O-ring **19** of flexible material. Due to the close tolerances required between the upper portion of tube **16** and the surface of disc **11** the tube must be firmly positioned and thus set screw **18** is located to bear against the middle of the lower collar of tube **16** with a substantial area of the collar snugly fitted against tube support **15** both above and below the set screw.

A back plate **20** having an axial passageway communicating with stationary feed tube **16** is securely mounted on the lower end of stationary tube support **15**. Liquid coating material to be atomized is fed from a reservoir **22** at a controlled rate by a supply tube **21** upwardly through the passageway in back plate **20** to the interior of feed tube **16**. Atomizing device **10** may be maintained at high electrical potential by connection to a high voltage source **24** as shown or other means known to the art employed to effect a particle-depositing potential difference

between the atomized coating material and the articles. This is generally accomplished by maintaining the articles and their supports at a difference of potential from the atomizer, preferably by grounding the articles and maintaining the atomizer at high voltage as shown.

Fig. 2 shows the details of stationary feed tube **16** with its upper liquid-discharging portion shown in cross section. To feed liquid coating material smoothly and without turbulence to disc **11**, stationary feed device **16** has an upper dome-like portion terminating in an annular liquid discharge edge **16***a* over which the liquid coating material flows for transference to the upper surface of the disc where centrifugal force will cause the liquid to spread into an outwardly moving thin film for atomization from the annular edge of the disc. It was found, however, that there is a tendency for a portion of the liquid to "creep" inwardly along either or both the under surface of the dome-like upper portion of feed tube **16** and the upper surface of the disc toward the axis of the atomizing device. Such inward liquid movement is, of course, undesirable since liquid may eventually reach the bearing structure and other interior moving parts. This can be prevented by making the gap between liquid discharge edge **16***a* and the upper surface of disc **11** less than .05 inch and preferably not more than .015 inch and also by making edge **16***a* relatively sharp or knife-like. It was also found desirable that edge **16***a* lie at least as close to the upper surface of the disc as does any other portion of tube **16**. In the embodiment shown this is done by providing a surface **16***b* extending inwardly from edge **16***a* substantially parallel to the surface of disc **11**.

In order to prevent the further movement of any liquid coating material which might creep beyond edge **16***a* and surface **16***b* and inwardly along the under surface of the dome, a downwardly depending drip skirt **16***c* was formed on the underside of the dome-like upper portion of feed tube **16**. Preferably drip skirt **16***c* has a lower edge of knife-like sharpness. The lower edge of the drip skirt should extend no lower than the plane of liquid discharge edge **16**a and preferably is somewhat above such plane. To further prevent liquid movement along the surface of the disc toward its axis, disc **11** may include an upstanding vertical extension or liquid dam **11***a* extending upwardly from the horizontal surface of the disc beneath the dome-like upper portion of feed tube **16**.

In certain spray coating operations it is desirable to tilt the disc so that the axis of atomizer **10** is not necessarily vertical but may be at an angle of as much as 45° to the vertical. Feed tube **16** as shown will perform satisfactorily in such attitudes, even though in such inclined attitudes liquid will be transferred to the disc from only the lowermost segment of tube edge **16***a*. Preferably, in order to provide for supported liquid flow along the upper surface of the dome to the disc, the upper surface of the domed portion of the feed tube is at an angle of approximately 40° to the surface of the disc, that is, a line in the direction of liquid flow on the upper surface of the dome over which liquid flows to discharge edge **16***a* will intersect the liquid-guiding upper surface of the disc at an angle of approximately 40°. Such an arrangement will permit the axis of atomizer **10** to be substantially tipped from the vertical and still provide a surface of the feed tube along which liquid may flow at a controlled rate downwardly due to gravity to the upper surface of the rotating disc.

Stationary feed tube **16** has a further advantage. When the atomizing device is stopped it is usually desirable to clean the film of liquid coating material from its upper surface to prevent drying and this is customarily done by wiping the upper surface of the disc with a solvent-soaked rag. Excess solvent and paint from this wiping operation can in no way reach the bearings or other interior moving parts of atomizing device **10** because of the umbrella effect of the dome-like upper portion of stationary feed tube **16** and the physical barriers of drip skirt **16***c* and dam **11***a*. Thus the use of stationary tube **16** affords protection to the bearing structure of the atomizing device both when the device is rotating and stationary.

One commonly used atomizing device embodying our invention includes a flat disc on the upper end of a rotatable hollow shaft having an inner diameter of approximately 0.75 inch. Various coating operations carried on with this device require liquid to be fed generally upwardly to the surface of the atomizing disc at rates of from 15 to 900 cubic centimeters per minute. The disc may be rotated at speeds of from several hundred to several thousand revolutions per minute. A tube constructed in the form of stationary feed tube **16** was able to feed liquid coating material to the upper surface of the disc at deliveries and speeds within the above ranges and to effect transfer of the liquid smoothly and evenly without a tendency to produce slugging or other undesirable characteristics.

When used with a hollow shaft having an inner diameter of 0.75 inch, the inner diameter of the lower portion of feed tube **16** is approximately 0.25 inch. The dome-like upper portion of the tube is smoothly formed with the upper surface of the tube, which terminates in liquid discharge edge **16***a*, making an angle of approximately 40° with the upper surface of the disc. Liquid discharge edge **16***a*, formed by the intersection of the upper dome-like surface of the tube and surface **16***b* is relatively sharp. Circular edge **16***a* has a diameter of about two inches. Surface **16***b* extends parallel to the upper surface of the disc a distance of approximately 0.1 inch measured radially in the direction of liquid flow. Drip skirt **16***c* has a diameter of approximately 1.25 inches and its knife-like lower edge is spaced approximately .03 inch above surface **16***b*. Dam **11***a* extends vertically approximately 0.5 inch above the upper surface of disc **11**.

In order to fit feed tube **16** into its position with the proper spacing between the upper surface of disc **11** and the surface **16***b* of the feed tube, uppermost inner portion **16***d* of feed tube **16** is threaded as shown. A suitable positioning tool having a threaded element can thus be screwed into threaded portion **16***d* of the feed tube to hold it for insertion downwardly through shaft **12** with O-ring **19** previously fitted into the annular groove around tube **16**. Tube **16** can then be positioned by proper gauges and temporarily held in this position by the tool while set screw **18** is screwed into place to firmly position the stationary tube. The tool may also be used to easily remove the feed tube from the atomizing device without damage after loosening set screw **18**.

Referring now to Figs. 3 and 4 there is shown a second type of atomizing device **30** which includes a flaring atomizing bell **31** mounted on one end of a generally horizontal rotatable hollow shaft **32** by an O-ring **33** and a set screw **34**. Bell **31** has an inner liquid-guiding surface with an innermost conical throat portion **31***a* extending outwardly from the juncture of bell **31** and shaft **32** toward the bell's annular edge at an angle of approximately 15° to the axis of the bell and shaft. The bell and shaft are rotated by an integral motor assembly lying within atomizer housing **35** whose details are not shown as our invention is independent of the motor or other driving means for bell **31** and shaft **32**.

Shaft **32** extends axially through housing **35**. At its opposite end there is affixed to housing **35** a stationary tube support **36** having an axial passageway concentric with the shaft. A hollow cylindrical tube stop **37** is positioned within the passageway in tube support **36** by a set screw **37***a*. A stationary feed tube **38** is securely mounted concentrically within the passageway in stationary tube support **36** with its one end against tube stop **37** by means of a set screw **39** and sealed by an O-ring **40** of flexible material. A back plate **41** having an axial passageway

communicating with the passageway in tube support **36** is securely mounted on the open face of the stationary tube support. Liquid coating material to be atomized is fed from a reservoir **44** at a controlled rate by a supply tube **45** through the passageway in back plate **41** and through tube stop **37** to the interior of feed tube **38**. Atomizing device **10** is maintained at a high electrical potential by connection to a high voltage source **46** as shown.

Fig. 4 shows the details of stationary feed tube **38** with its forward liquid discharging portion shown in cross-section. In order to properly feed liquid coating material to the inner surface **31***a* of bell **31**, stationary feed tube **38** terminates in a forward portion having a flat disc-like surface **38***a* which lies substantially normal to the axis of the feed tube. Surface **38***a* terminates in an annular liquid discharge edge **38***b* preferably of knife-like sharpness which lies closely adjacent to the inner surface of the bell. On the opposite surface of the tube from surface **38***a* is a cylindrical knife-edge projection or drip skirt **38***c* extending rearwardly toward shaft **32**. When the stationary feed tube is properly assembled within atomizer **30** its edge **38***b* lies concentric with the throat-like interior surface **31***a* of the bell and spaced less than .05 inch from surface **31***a*.

In order to further prevent liquid coating material from reaching the bearing structure of atomizer **30** a cylindrical sleeve or liquid dam **47** is pressed into the throat of bell **31**. Liquid dam **47** is concentric with bell **31**, shaft **32** and feed tube **38**. It extends forwardly into the central passageway formed by surface **31***a* of the bell so its foremost end lies beneath the knife-edge of drip skirt **38***c*. Thus any liquid "creeping" back along surface **31***a* toward shaft **32** will be stopped by dam **47**. The dam will also tend to prevent any liquid dripping from the edge of drip skirt **38***c* from reaching the interior of the atomizer.

One commercially used atomizing device of the type shown in Fig. 3 which embodies our invention includes a rotating hollow shaft having an inner diameter of approximately 0.75 inch and a bell in which surface **31***a* makes an angle of approximatey 15° with the axis of the bell and shaft. Various coating operations using this atomizing device require liquid to be fed generally horizontally to surface **31***a* of the atomizing bell at rates of from 15 to 900 centimeters per minute. The bell may be rotated at speeds of from several hundred to several thousands of revolutions per minute. A tube in the form of stationary feed tube **38** will feed liquid coating material to inner surface of the bell at deliveries and speeds within the above ranges and effect transfer of the liquid smoothly and evenly without slugging or other undesirable characteristics.

When the hollow shaft has an inner diameter of 0.75 inch and surface **31***a* inclined at an angle of 15°, the inner diameter of feed tube **38** is approximately 0.25 inch. Liquid discharge edge **38***b* of the tube is of knife-like sharpness and has a diameter of approximately 1.2 inches. Edge **38***b* is formed by the intersection of two surfaces which make the angle of edge **38***b* approximately 10°. Drip skirt **38***c* has a diameter of about one inch and extends approximately 0.3 inch rearwardly from surface **38***a*. Liquid dam **47** is approximately 1 inch in length and extends within the recess formed between the wall of stationary tube **38** and drip skirt **38***c* as shown. Like tube **16**, feed tube **38** is threaded at **38***d* for ease of insertion and removal from the atomizer.

We claim:

1. In an electrostatic spray coating system, a device for feeding liquid coating material comprising a rotatable hollow shaft, an annular-edged atomizer concentrically mounted for rotation on one end of said shaft, said atomizer having an extended liquid-guiding surface leading to its annular edge, a stationary feed tube extending through said hollow shaft and terminating in a sharp annular liquid discharge edge closely spaced from the extended surface of said atomizer, said discharge edge being concentric with and substantially equally spaced from the liquid-guiding surface of said atomizer, means for rotating said shaft and atomizer about their axes, and means for feeding liquid at a controlled rate to said feed tube for flow therethrough and over its liquid discharge edge to the liquid-guiding surface of the rotating atomizer to form thereon an expanding liquid film for atomization from the edge of said atomizer.

2. In an electrostatic spray coating system, a device for feeding liquid coating material comprising a rotatable hollow shaft, an annular-edged atomizer concentrically mounted for rotation on one end of said shaft, said atomizer having an extended liquid-guiding surface leading to its annular edge, a stationary feed tube extending through said hollow shaft and terminating in a sharp annular liquid discharge edge closely spaced from the extended surface of said atomizer, said discharge edge having a diameter of approximately two inches concentric with and substantially equally spaced from the liquid-guiding surface of said atomizer and lying at least as close to said liquid-guiding surface as does any other portion of the feed tube, means for rotating said shaft and atomizer about their axis, and means for feeding liquid at a controlled rate to said feed tube for flow therethrough and over its liquid discharge edge to the liquid guiding surface of the rotating atomizer to form thereon an expanding liquid film for atomization from the edge of said atomizer, a line in the direction of liquid flow on the surface of said feed tube over which liquid flows to the liquid discharge edge of the stationary feed tube intersecting the liquid-guiding surface of the atomizer at an angle of approximately 40°.

3. Apparatus as set forth in claim 1 wherein the feed tube terminates in a dome-like portion and includes a knife-edged drip skirt on the underside of said dome-like portion within the annular liquid discharge edge of the feed tube.

4. Apparatus as set forth in claim 3 wherein the rotating atomizer includes a liquid dam extending upwardly from the liquid-guiding surface of the atomizer beneath the dome-like portion of the feed tube beyond the edge of the drip skirt on the under side of said dome-like portion.

5. Apparatus as set forth in claim 4 wherein the angle between the liquid-guiding surface of the atomizer and the outer dome-like surface of the feed tube adjacent the liquid discharge edge of said feed tube is approximately 40°.

6. Apparatus as set forth in claim 1 wherein the stationary feed tube includes a generally cylindrical knife-edged drip skirt lying adjacent to the liquid discharge edge of the feed tube, and the rotating atomizer includes a liquid dam projecting from the liquid-guiding surface of the atomizer and surrounded by the knife edge of the drip skirt.

7. An atomizing apparatus comprising a housing enclosing an electric motor having a rotatable hollow shaft, an annular-edged atomizer mounted for rotation on one end of said shaft, said atomizer having an extended liquid-guiding surface, a removable stationary feed tube extending concentrically through said shaft and terminating at one end in a liquid discharge edge lying closely adjacent the liquid-guiding surface of said atomizer, a portion of the inner surface of the feed tube being threaded, a stationary tube support affixed to said housing maintained in fixed spaced relation to the end of said shaft opposite said atomizer, an O-ring of resilient material mounted concentrically in an annular groove in the outer surface of said stationary feed tube, said O-ring being positioned to fit snugly against said tube support, a set screw positioned radially within said tube support, the end of said stationary tube opposite said liquid discharge edge being positioned within said tube support and firmly held by said set screw, said feed tube being removable from said apparatus by loosening said set screw, fitting a threaded

tool into the threaded portion of said feed tube and drawing the feed tube axially out of said hollow shaft.

8. An atomizing apparatus comprising a rotatable hollow shaft, a bell-shaped atomizer mounted for rotation on said shaft, said atomizer having an interior surface portion flaring outwardly at an angle to the axis of said shaft and bell of approximately 15°; a hollow stationary feed device extending concentrically through said shaft and terminating at one end in a sharp annular liquid discharge edge lying closely adjacent to and equidistant from the conical interior surface portion of said atomizer, said sharp edge being formed by two intersecting surfaces of the feed device one of which is flat and lies substantially normal to the axis of said device; means for rotating said shaft and atomizer; and means for feeding liquid through said feed device and over its liquid discharge edge to the interior surface portion of said rotating atomizer.

9. An atomizing apparatus comprising a rotatable hollow shaft; an annular-edged atomizing bell concentrically mounted for rotation on one end of said shaft, said bell having an inner surface flaring outwardly to the annular edge of said bell; a generally cylindrical liquid dam mounted at one of its ends within the inner surface of said bell concentrically with the axis of said bell with the other end of said cylindrical dam projecting toward the annular edge of said bell; a stationary feed device extending concentrically through said hollow shaft and terminating at one end in a lipped portion having an edge overhanging the projecting end of said liquid dam; means for rotating said shaft, bell and dam; and means for feeding liquid to said feed device for flow therethrough and over said lipped portion to the inner surface of the rotating bell.

10. An atomizing apparatus for use in an electrostatic coating system comprising a rotatable hollow shaft; an atomizing bell concentrically mounted for rotation on one end of said shaft, said bell having an inner surface portion flaring conically at an angle to the axis of said shaft of approximately 15°; a cylindrical liquid dam mounted at one of its ends within the inner surface portion of said bell concentrically with the axis of said bell with the other end of said cylindrical dam projecting from said inner surface portion; a stationary feed tube extending concentrically through said hollow shaft and terminating in a lipped portion having a liquid discharge edge overhanging the projecting edge of said liquid dam; means for rotating said shaft, bell and dam; and means for feeding liquid to said feed tube for flow therethrough and over said liquid discharge edge to the inner surface of the rotating bell.

11. In an electrostatic spray coating system, a device for feeding liquid coating material comprising a rotatable hollow shaft, an annular-edged atomizer concentrically mounted for rotation on one end of said shaft, said atomizer having an extended liquid-guiding surface leading directly to its annular edge and including a cylindrical liquid dam projecting from the liquid-guiding surface, a stationary feed tube extending through said hollow shaft and terminating in a sharp annular liquid discharge edge concentric with and spaced less than .05 inch from the extended liquid-guiding surface of said atomizer, said feed tube having a knife-edged drip skirt surrounding the liquid dam of said atomizer, means for rotating said shaft and atomizer about their axes, and means for feeding liquid at a controlled rate to said feed tube for flow therethrough and over its liquid discharge edge to the liquid-guiding surface of the rotating atomizer to form thereon an expanding liquid film for atomization from the edge of said atomizer.

12. In an electrostatic spray coating system, a device for feeding liquid coating material comprising a rotatable hollow shaft, an annular-edged atomizer concentrically mounted for rotation on one end of said shaft, said atomizer having an extended liquid-guiding surface leading to its annular edge, a stationary feed tube extending through said hollow shaft and terminating in an annular liquid discharge edge spaced from the extended surface of said atomizer, said discharge edge being concentric with and substantially equally spaced from the liquid-guiding surface of said atomizer, said feed tube including a drip skirt on the under side of said feed tube and surrounded by said discharge edge, means for rotating said shaft and atomizer about their axes, and means for feeding liquid at a controlled rate to said feed tube for flow therethrough and over its liquid discharge edge to the liquid-guiding surface of the rotating atomizer to form thereon an expanding liquid film for atomization from the edge of said atomizer.

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