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(54) **Method and apparatus for inductively charging centrifugally atomized conductive coating material.**

(57) Electrostatic spray coating method and apparatus, for spraying conductive coating material, utilizing nonconductive rotating cup-shaped atomizer and a charge-inducing electrode proximate the periphery of the rotating cup whereat atomization occurs. The electrode, which is charged to one polarity from an electrostatic source, induces opposite polarity charge on the atomized particles. The charged particles are then attracted toward an object to be coated which is maintained at a potential sufficiently different to attract the charged particles to facilitate deposition of the coating on the object. The conductive coating can be either inherently conductive material, e.g. water-based paint, or nonconductive material, such as, solvent-based paint, which has been doped to render it conductive.

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METHOD AND APPARATUS FOR INDUCTIVELY CHAPGING CENTRIFUGALLY ATOMIZED CONDUCTIVE COATING MATERIAL

This invention relates to electrostatic coating, and more particularly to electrostatic coating apparatus and methods utilizing rotary atomizers for spraying electrically conductive coatings.

Electrically conductive rotating cups, or "bells" as they are frequently termed, connected to a source of electrostatic potential and supplied with nonatomized coating material, have been employed for many years to simultaneously atomize the spray coating material as well as electrostatically charge it to the potential and polarity of the electrostatic source. The atomization is accomplished centrifugally as the film of coating material on the inside of the conically-shaped rotating bell is driven radially outwardly from the periphery of the bell by centrifugal force, forming a mist of atomized particles. Electrostatic charging of these atomized particles is accomplished by maintaining the rotary conductive bell at an electrostatic potential sufficiently high to produce a corona discharge at the bell periphery whereat centrifugal atomization occurs. The corona discharge creates ions which collide with the atomized coating particles, charging them with the same polarity as the electrostatic high voltage source to which the conductive

atomizing bell is connected.

A very serious disadvantage of the prior art rotary conducting atomizing bell is that the bell, which functions as a capacitor of considerable electrical energy storage capability, exhibits an extremely short relaxation time constant because of its conductive properties. (The relaxation time constant (seconds) of an object which stores electrical energy in capacitive form, such as a conductive bell atomizer, is proportional to the product of a) the dielectric constant of the material (farads/meter) and b) the resistivity of the material (ohms-meter).) Since the magnitude of a capacitor's relaxation time constant is proportional to the rate at which the capacitor discharges stored energy, a capacitive object, such as a conductive atomizing bell, having a short relaxation time constant will discharge capacitively stored energy at a high rate. As a consequence, should the conductive atomizing bell of the prior art contact or approach a grounded object and the capacitively stored energy discharge at a high rate, a spark can be created having sufficient energy to ignite the coating environment when solvent-based coatings are used. Additionally, should an operator contact the electrically charged conductive bell, a substantial electrical

shock can result by reason of the rapid discharge rate which results.

Accordingly, it has been an objective of this invention to provide an electrostatic spray coating apparatus utilizing a rotary atomizer which does not create safety hazards by discharging electrical energy stored in capacitive form at unduly large rates sufficient to induce shock or ignition. This objective has been accomplished, in accordance with this invention, by providing, in conjunction with a source of conductive coating material, a nonconductive rotating atomizer, preferably a bell, with a charging electrode located proximate the periphery of the bell whereat atomization occurs which induces a charge on the atomized conductive coating particles having a polarity which is opposite to that of the electrostatic source to which the charge-inducing electrode is connected.

A very important advantage of the apparatus and method of this invention is that the rotary atomizing bell, since it is fabricated of electrically nonconductive material, exhibits a large relaxation time constant for the discharge of capacitively stored electrical energy. As a consequence, it does not permit discharge of capacitively stored electrical energy at rates sufficient to induce shock or ignition if the rotating nonconductive bell of this invention

is inadvertently electrically grounded or contacted by an operator.

Another very important advantage of this invention, attributable particularly to utilization of inductive particle charging instead of corona discharge heretofore utilized in prior art electrostatic rotary atomizers using conductive bells, is that the voltage levels typically required for inductive charging are substantially less than that required to create a corona discharge. As a consequence, the amount of energy stored in electrical form, which is proportional to the square of the voltage, is significantly reduced. Additionally, since the voltage levels are lower with inductive particle charging, the electrostatic voltage source, as well as the interconnecting cables, are significantly less expensive to construct.

In a preferred embodiment of the invention, a repelling electrode maintained at the same polarity as that of the charged particles is provided rearwardly of the edge of the atomizing bell whereat atomization and charging of the particles occurs. The repelling electrode functions to repel the charged coating particles, thereby inhibiting rearward movement of the coating material and deposit thereof on the atomizer housing.

In accordance with a further embodiment of the invention, and by reason of the use of a conductive coating material, the coating material is pre-charged

prior to introduction onto the nonconductive atomizing bell. The charge on the atomized conductive coating particles is substantially increased by an inductive charging electrode which is maintained at a potential less than, but of the same polarity as, the electrostatic source which pre-charged the coating. Since the polarity of the inductive charging element is the same as that of the pre-charged conductive coating material prior to introduction into the rotary atomizer, the charge on the particles induced by the inducing electrode effectively increases the initial charge on the coating material to a level correlated to the difference between the electrostatic potential of the source which initially charged the coating and the electrostatic potential of the source to which the charge-inducing electrode is connected. Stated differently, since the magnitude of the electrostatic source to which the charge-inducing electrode is connected is less than that of the electrostatic source which initially charged the conductive coating material, but of the same polarity, the polarity of the pre-charged coating particles remains unchanged after inductive charging, although the charge thereon is substantially increased in magnitude. An important advantage of this embodiment of the invention, in addition to the substantial reduction in discharge rate of capacitively stored energy obtained by reason of the use of a nonconductive bell, is that the

polarity of the charge on the atomized conductive coating particles is the same as that on the charge-inducing electrode and the repelling electrode, minimizing the deposition of charged coating particles on the repelling and charge-inducing electrodes.

In accordance with a further aspect of the invention, the charge-inducing electrode is located within the mouth of the bell and provided with a dome shape. This reduces the deposition of charged conductive coating particles on the charge-inducing electrode which tends to occur as a consequence of a vortex flow pattern created by the spinning bell. That is, the dome-shaped charge-inducing electrode substantially eliminates the vortex flow, thereby minimizing deposition of charged coating material on the charge-inducing electrode.

In accordance with a further feature of the invention, the charge-inducing electrode is mounted for movement with the atomizing bell. As a consequence of rotating the charge-inducing electrode at high speed, any conductive coating material deposited thereon is centrifugally ejected, avoiding accumulation of coating material on the electrode.

These and other features, advantages, and objectives of the invention will become more readily apparent from a detailed description of the preferred embodiments thereof taken in conjunction with the drawings in which:

Figure 1 is an elevational view, partially in cross-section, schematically showing the principal components of one preferred embodiment of a spray coating system for conductive coatings incorporating the principles of this invention.

Figure 2 is a side elevational view of the rotary atomizer and associated electrodes which constitute elements of the system shown in Figure 1.

Figure 3 is an elevational view, partially in cross-section, of another preferred embodiment of electrostatic spray coating system for conductive coatings incorporating the principles of this invention, and

Figure 4 is a perspective view of the atomizer housing with a modified form of repelling electrode mounted thereon.

The spray coating system of this invention, in one of the preferred embodiments thereof shown in Figures 1 and 2, includes a rotary atomizer 10 having as a principal element thereof a rotating cup or bell 12. The rotating cup 12, in a manner well known to those skilled in the art, provides under the action of centrifugal force a stream of atomized coating particles 14 at an emission zone 16 located proximate the periphery 18 of the rotating atomizing cup. Also included in the electrostatic spray coating apparatus depicted in Figures 1 and 2 are conductive charge-inducing electrodes which, in a preferred form,

include an internal particle-charging electrode 20 and an external particle-charging electrode 22. The internal and external particle-charging electrodes 20 and 22 induce charges on the atomized particles in the stream 14 at the emission zone 16 which are opposite in polarity to the polarity of the charge-inducing electrodes 20 and 22. The charged particles in stream 14, in a manner well known to those skilled in the art, are electrostatically attracted toward an object 24 to be coated which is maintained, via wire 25 and grounded electrostatic voltage source 27, at a potential sufficiently different from that of the charged particles to electrostatically attract the charged particles for deposition on the object 24.

The rotary atomizer 10, considered in greater detail in connection with Figure 1, includes a nonrotating electrically nonconductive housing 26 which may be stationarily mounted for spraying objects 24 moving therepast on a conveyor or the like. Alternatively, the housing 26 may be portable to facilitate manual spray coating of objects 24 which are either stationary or moving. The housing 26 is provided with a longitudinal bore 28 within which is located a shaft 29 rotatable about a horizontal axis 29a in a pair of bearings 30, 31. The shaft 29, like the housing 26, is preferably fabricated of material which is not electrically conductive. A turbine 32 of any suitable construction is mounted to the end sur-

face 26a of the housing 26 and drivingly coupled to the rear end of the shaft 29 (left end as viewed in Figure 1) for rotating the shaft at a desired rate, such as, 30,000 revolutions per minute, sufficient for centrifugal atomization of the coating material by the rotating cup 12.

At the forward end of the shaft 29 the rotary atomizing element, bell, or cup 12 is mounted for rotation therewith, as is the internal charge-inducer 20. For reasons to become more apparent hereafter, the cup 12 is fabricated of an electrically nonconductive material. For reasons also to become more apparent hereafter, the internal inductor 20 has an external shape in the form of a dome.

The cup 12, considered in more detail, includes a generally frusto-conical, tubular wall section 40 which is separated into forward and rearward sections 40a and 40b by an integral vertical disc-shaped wall 42 having a circularly arranged array of openings 44. The liquid coating material, which must be conductive, such as nonconductive solvent-based paint which has been doped to render it conductive, or water-based paint which is conductive without doping, is injected into the cavity 46 formed by the rearward portion 40b of the wall 40 and the disc 42 and passes forwardly through the openings 44 in wall 42. Coating material entering the forward chamber 50 via openings 44 forms a film F on the interior surface of the

forward wall section 40a which advances forwardly and radially outwardly under centrifugal force, ultimately producing a stream of atomized particles 14 at the emission zone 16. The conductive coating material is supplied to the conduit 48 from a suitable pressurized coating supply tank 54.

The stream of atomized particles 14 in the region of the emission zone 16 has a generally circular cross-section. If desired, the stream of atomized particles 14 can be shaped by a suitably configured stream of air emanating from an appropriately shaped nozzle 60 formed in the forward end 26b of the housing 26. For example, if it is desired to shape the stream of atomized particles 14 into an oval pattern, the nozzle 60 can be oval-shaped. A source of pressurized air 62 connects to the nozzle 60 via an air hose 64. The shaping air emanating from the nozzle 60 is directed in the forward direction, and shapes the atomized particle stream 14 when it impinges thereon from the rear.

Mounted on the outer surface of the forward wall section 40a of the cup 12 is the external charge inducer 22 which is fabricated of electrically conductive material. The external charge inducer 22, while susceptive of a variety of configurations, in a preferred form is generally frusto-conical, terminating in a leading edge 22a located slightly to the rear and

outwardly of the periphery 18 of the atomizing cup whereat the atomized particles are formed.

The internal and external inductors 20 and 22 are charged, preferably positively, from an electrostatic potential source 70, in a manner to be described, for inductively charging the conductive coating particles of the stream 14 in the emission zone 16 with a polarity opposite to that of the polarity of the charge inducers 20 and 22. The charging of the particles of the stream 14 in the emission zone 16, in addition to facilitating attraction thereof toward the object 24 to be coated which is maintained at a different potential by the suitable source 27, also functions to enhance the degree of atomization of the stream 14 since the particles, charged to the same polarity, repel each other.

The internal inductor 20 is electrically connected to the source of electrostatic potential 70 by an electrically conductive path which includes a wire 78 located in a suitably provided bore in the forward portion of the shaft 29, the wire 78 being connected at its forward end to the internal inductor 20 and at its rearward end to an electrically conductive ring 80 mounted on the exterior of the shaft 29 forward of the bearing 31. Also included in the conductive path between inductor 20 and source 70 is a conductive brush 82 mounted to the wall of the bore 29 in alignment with the conductive ring 80 which is in

wiping contact therewith, and an electrical conductor 84 between the source 70 and the brush 82. The external inductor 22 is connected to wire 78, and in turn to the electrostatic voltage source 70, by an insulated conductive wire 79 molded into the disc 42 and the wall section 40a.

An open-ended cylinder 86 forming an integral part of the cup 12, extends rearwardly from the conical shell 40 at a point proximate the intersection therewith of the disc 42. The cylinder 86 cooperates with a forwardly extending cylinder 88 formed on the forward surface 26b of the housing 26. The concentric cylinders 86 and 88 function to seal the chamber 46 from the environment.

A conductive repelling electrode 90, preferably in the form of a ring, is mounted exterior to the cup section 40a by a plurality of axially disposed nonconductive spokes 92 extending forwardly from the front wall 26b of the housing 26. The repelling ring 90 is electrically connected to a source of electrostatic potential 94 having a polarity which is the same as the polarity of the charged particles in the stream 14, preferably a negative polarity of approximately -20Kv. The connection between the ring 90 and the source 94 is established by conductive wire 98. The repelling ring 90, by reason of being maintained at a polarity opposite to that of the charge on the particles of the stream 14, functions to minimize a

condition known as "sprayback" in which the charged particles in the stream 14 migrate rearwardly and deposit on the housing 26.

By reason of the inductors 20 and 22 being rotated at high speed with the cup 12, particles deposited thereon are centrifugally ejected, preventing the accumulation of coating material on the inductors.

Figure 3 schematically shows another preferred embodiment of a spray coating system for conductive coatings incorporating the principles of this invention. For convenience, components of the system depicted in Figure 3 which are structurally similar to components of the system shown in Figures 1 and 2 are provided with the same reference numerals. Accordingly, the system of Figure 3, like the system of Figure 1, includes a rotary atomizer 10 having an atomizing cup 12 driven by a shaft 29 from a turbine 32 which provides a stream of atomized particles 14 at an emission zone 16. The stream of conductive spray coating particles 14 is shaped by a nozzle 60 supplied from a pressurized air source 62 via a line 64. A repelling electrode 90 is mounted exterior to the cup 12 by nonconductive spokes 92 which extend forwardly from housing wall 26b. Repelling electrode 90 functions to inhibit sprayback of coating material from the stream 14 to the atomizer housing 26.

The system of Figure 3, unlike the system of Figure 1, is provided with only a single inductor 20

mounted to the forward end of the shaft 29 for rotation therewith, the function of which will be discussed in more detail hereafter. In the system of Figure 3, as in the system of Figure 1, the spray coating material supplied from pressurized source 54 is either inherently electrically conductive or is injected with a suitable doping agent to render it conductive. As such, it can be maintained at a substantial negative potential, for example, -60Kv, by a suitable high voltage electrostatic source 100 via an electrical conductor 102 which is in electrical contact with the coating material in the tank 54. If the tank 54 is itself fabricated of electrically conductive material, the tank is electrically isolated from ground potential by insulative supports 54a and 54b. Maintenance of the coating in tank 54 at -60Kv potential, produces some negative charging of the conductive coating prior to atomization through the contact charging technique.

The charging technique utilized in conjunction with the system depicted in Figure 3 involves, in addition to contact negative charging of the conductive coating material from the source 100, substantial additional negative charging as a result of inductive charging of the atomized particles in stream 14 with the inductor 20 which is connected to a source 106 of negative potential slightly lower in magnitude than the source of negative potential 100.

Preferably, the source 106 charges the inductor 20 to -57Kv via conductor 84, brush 82, ring 80, and wire 78. Since the inductor 20 is maintained at a negative potential of -57Kv, it induces additional negative charge on the atomized particles in the stream 14. More particularly, the conductive coating material, by reason of being maintained at -60Kv, effectively perceives the -57Kv inductor 20 as an inductor at +3Kv. The +3Kv inductor 20 induces opposite polarity charge, that is, negative charge, on the coating. This induced charge is in addition to the negative charge already on the coating by reason of contact charging from the -60Kv source. The negatively charged particle stream 14 is attracted to the object 24, which is maintained by the source 74 at a potential sufficiently different than the charge on the particles to attract the particles and deposit them on the object.

With the atomized particles in the stream 14 having a negative charge, the charged particles are repelled by both the repelling ring 90 and the inductor 20, thereby minimizing the tendency of the particles to coat on either the inductor 20 or the repelling ring 90. Additionally, the repelling ring 90, by reason of being located rearwardly of the emission zone 16, minimizes sprayback, that is, deposition of the negatively charged coating particles on the housing 26.

In the embodiment of Figure 3, like in the embodiment of Figures 1 and 2, the inductor 20 rotates with the cup 16 to centrifugally eject from the inductor 20 any paint particles which are deposited thereon, preventing an accumulation of coating material on the inductor.

The spray coating systems of Figures 1, 2 and 3 provide a number of very important advantages. For example, since electrostatic charging of the conductive particles is done inductively, with or without prior contact charging in the event the coating material is pre-charged prior to atomization, a corona discharge found in prior art electrostatic charging systems using conductive atomizing cups maintained at charging potentials, is unnecessary. As a consequence, the atomizing cup can be fabricated of nonconductive material, considerably reducing the discharge rate of energy stored in the system in capacitive form, which in turn very substantially reduces the risk of electrical shock and/or ignition should the atomizing cup be electrically grounded or approach a grounded object.

Additionally, and also by reason of the absence of corona charging, the charging voltage levels required for a given coating transfer efficiency can be much lower than typically required in bell-type electrostatic coating systems of the type in which a conductive bell is used to charge the spray

coating particles. The reduction in magnitude of the electrostatic voltage required reduces the cost of the system since the cable which interconnects the high voltage source to the inductive charging electrode of this invention need not be insulated for voltages as high as typically found in prior art rotary atomizers utilizing corona charging.

A still further advantage, attributable to the fact that the charging inductor is located proximate the forward end of the atomizing cup within the generally circular cross-section stream of atomized particles, is that the repelling electrode located exteriorly and behind the stream can be of relatively simplified shape, such as a ring.

A further advantage found in the embodiment of Figures 1 and 2 is that sprayback can be minimized utilizing repelling electrodes connected to relatively low voltage supplies due to the relatively high charge on the particles induced by the inductor electrode.

Another advantage of the invention, particularly the embodiment of Figures 1 and 2, is that since inductive particle charging is utilized, very little electrical power is required. For example, there is no electrical power consumed in the induction charging circuit which includes the induction charging electrodes 20 and 22, the high voltage source 70 to which it is connected, the wire 78, ring 80, brush 82, and wire 84. The only electrical current existing in the

system of Figures 1 and 2 is the negative charge flow from ground through the path which includes the grounded power supply 27, conductor 25, object 24, charged coating particles in stream 14, coating film F and the coating stream in hose 48, coating in tank 54, and the grounded tank.

In the embodiment shown in Figure 3, there is no electrical current flow in the inductive charging circuit consisting of the inductor 20, wire 78, ring 80, brush 82, conductor 84, and grounded power supply 106. There is, of course, a charge flow in a path which includes grounded power supply 100; conductor 102; charged coating in tank 54 and the charged coating in the hose 48 which are contact charged by the source 100; the stream of atomized charged particles 14 in which the charge has been inductively increased by the inductor 20; object 24; conductor 25; and grounded source 74.

A further advantage of the invention, particularly attributable to the dome-shaped forward external configuration of the internal inductor 20, is that the tendency of the atomized stream of particles 14 to deposit on the inductor 20, as a consequence of a vortex flow established by the rotating cup, is very drastically reduced.

While the preferred embodiments of the invention have been described in connection with inductive charging of conductive coating on a noncon-

ductive atomizing cup, the inductive charging principles of this invention could be used with an atomizing cup fabricated of electrically conductive material, although such would increase the rate of discharge of capacitively stored electrical energy and the consequent risk of shock and ignition, as well as reduce the efficiency of the inductive charging process.

If desired, the stationary repelling ring 90 can be substituted by a plurality of stationary electrically conductive spheres arranged in a circular array about the atomizing cup 12, as best shown in Figure 4. Each of these spheres 110 is mounted to the housing 26 of the atomizer by a nonconductive spoke 92 and is electrically connected, via separate resistors 112, to a common conductor 113 on the atomizer housing which connects to a suitable electrostatic voltage source.

CLAIMS:

1. An electrostatic spray coating apparatus for coating objects maintained at an electrostatic potential substantially different from that of the electrostatic potential to which said spray coating is electrostatically charged, comprising: a rotary atomizer connectable to a source of electrically conductive coating material and providing a stream of atomized coating particles at an atomized particle emission zone, and a charge inducer located in charge-inducing relationship to atomized particles in the stream, the charge inducer being connectable to an electrostatic voltage source to inductively charge the stream of atomized particles to promote attraction thereof to an object to be coated which is maintained at an electrostatic potential substantially different from that to which the particles are charged, the rotary atomizer being electrically isolated from the charge inducer and the electrostatic voltage source.

2. Apparatus as claimed in Claim 1 wherein the atomizer includes a rotating bell-shaped member having a surface over which nonatomized coating flows under centrifugal force toward a peripheral section thereof proximate said particle emission zone from which atomized coating particles are centrifugally emitted to establish said atomized coating stream, said rotating member being substantially electrically nonconductive and electrically isolated from said charge inducer and the electrostatic voltage source to which the said charge inducer is connected, thereby

minimizing the rate of discharge of electrical energy capacitively stored by said rotary atomizer.

3. Apparatus as claimed in Claim 1 wherein the stream is of generally circular cross-section in the region of the emission zone characterised in that a repelling electrode is located exteriorly of the circular cross-section stream which is connectable to a source of electrostatic potential of the same polarity as that of said charged particles to inhibit movement of charged particles in a direction away from said object being spray coated.

4. Apparatus as claimed in Claim 1 wherein the stream is of generally circular cross-section in the region of said emission zone, and wherein the charge inducer includes internal and external charge-inducing elements respectively located interiorly and exteriorly of said circular cross-section stream.

5. Apparatus as claimed in Claim 1 wherein the stream is of generally circular cross-section in the region of the emission zone, and wherein the charge inducer is located interiorly of the circular cross-section stream, characterised in that a repelling electrode is located exteriorly of said circular cross-section stream which is connectable to a source of electrostatic potential of the same polarity as that of said charged particles to inhibit movement of charged particles in a direction away from said object being spray coated.

6. Apparatus as claimed in Claim 1 further including means for rotating the charge inducer to

eject therefrom under centrifugal force coating particles deposited thereon and thereby inhibit the accumulation of coating on the charge inducer.

7. Apparatus as claimed in Claim 1 wherein the stream is of generally circular cross-section in the region of the emission zone, and wherein the charge inducer includes internal and external charge-inducing elements respectively located interiorly and exteriorly of said circular cross-section stream, characterised in that means are provided for rotating said interior and exterior charge inducers to eject therefrom under centrifugal force coating particles deposited thereon and thereby inhibit the accumulation of coating on said interior and exterior inducers.

8. Apparatus as claimed in Claim 1 further including a source of pressurized gas for impinging and shaping said stream of atomized coating particles.

9. Apparatus as claimed in Claim 4 wherein said stream is of generally circular cross-section in the region of said emission zone, wherein said rotating member tends to create a vortex flow of electrostatically charged particles toward the center of said circular cross-section stream, and wherein said charge inducer is located interiorly of said circular cross-section stream and has a generally dome-shaped exterior surface to reduce said vortex flow of electrostatically charged particles toward said inducer and thereby minimize deposition of charged coating particles thereon.

10. Apparatus as claimed in Claim 1 wherein the

stream is of generally circular cross-section in the region of the emission zone, and wherein the charge inducer is located interiorly of the circular cross-section stream, characterised in that plural spherical spaced-apart repelling electrodes are located exteriorly of said circular cross-section stream which are each connectable via respectively different resistors to a source of electrostatic potential of the same polarity as that of said charged particles to inhibit movement of charged particles in a direction away from said object being coated.

11. An electrostatic spray coating system for coating objects maintained at an electrostatic potential substantially different from that of the electrostatic potential to which said spray coating is electrostatically charged, comprising: a source of nonatomized electrically conductive coating material, a rotary atomizer connected to said conductive coating source, said atomizer providing a generally circular cross-section stream of atomized coating particles at an atomized particle emission zone, a charge inducer located in charge-inducing relationship to atomized particles in said stream, said charge inducer being electrically isolated from said rotary atomizer, first electrostatic potential source means in electrical contact with said nonatomized electrically conductive coating material to electrically pre-charge said nonatomized conductive coating material prior to atomization by said rotary atomizer, second electrostatic potential source means having the same

polarity as said first source, but being lesser in magnitude, said second source being connected to said charge inducer to increase the charge on said pre-charged particles by inductively charging said stream of pre-charged atomized particles with a polarity the same as said polarity of said first and second sources and to a magnitude correlated to the difference between the magnitudes of said sources, whereby said inductively pre-charged particles are repelled from said inductor to minimize deposit thereon of said inductively charged particles, and means to maintain an object to be coated at a potential and polarity sufficient to electrostatically attract said inductively charged atomized particles toward said object.

12. A method of electrostatically coating an object with material, comprising the steps of: centrifugally atomizing electrically conductive liquid coating material with a rotating nonconductive member to produce a stream of atomized coating particles at an atomized particle emission zone, inducing an electrostatic charge on the atomized particles with a charge-inducing electrode which is located in charge-inducing relationship therewith and maintained at a polarity opposite to that of the charge induced on the particles, and maintaining the object to be coated at an electrostatic potential sufficiently different than that to which the particles are charged to attract and deposit the particles on the object.

13. A method as claimed in Claim 12 further

including the step of: pre-charging conductive coating material, prior to centrifugal atomization thereof, from a contact electrode in contact therewith which is maintained at an electrostatic voltage greater than that of the charge-inducing electrode, whereby subsequent induction charging by the charge-inducing electrode increases the charge on the pre-charged particles by an amount correlated to the difference in the electrostatic potential of the sources to which the contact electrode and charge-inducing electrode are connected.

14. A method as claimed in Claim 12 further including the step of: maintaining a repelling electrode, which is located on the side of the atomizing member opposite to that of the charge-inducing electrode, at the same polarity as that of the charged particles, to repel charged particles from the repelling electrode and inhibit migration thereof away from the object, thereby minimizing sprayback and deposit of charged particles on the nonrotating housing which mounts the rotating atomizing member.

15. A method as claimed in Claim 12 further including the step of: maintaining a repelling electrode, which is located on the side of the atomizing member opposite to that of the charge-inducing electrode, at the same polarity as that of the charged particles, to repel charged particles from the repelling electrode and inhibit migration thereof away from the object, thereby

minimizing sprayback and deposit of charged particles on the nonrotating housing which mounts the rotating atomizing member, and rotating the charge-inducing electrode to centrifugally eject charged particles deposited thereon and thereby minimize the accumulation of coating on the charge-inducing electrode.

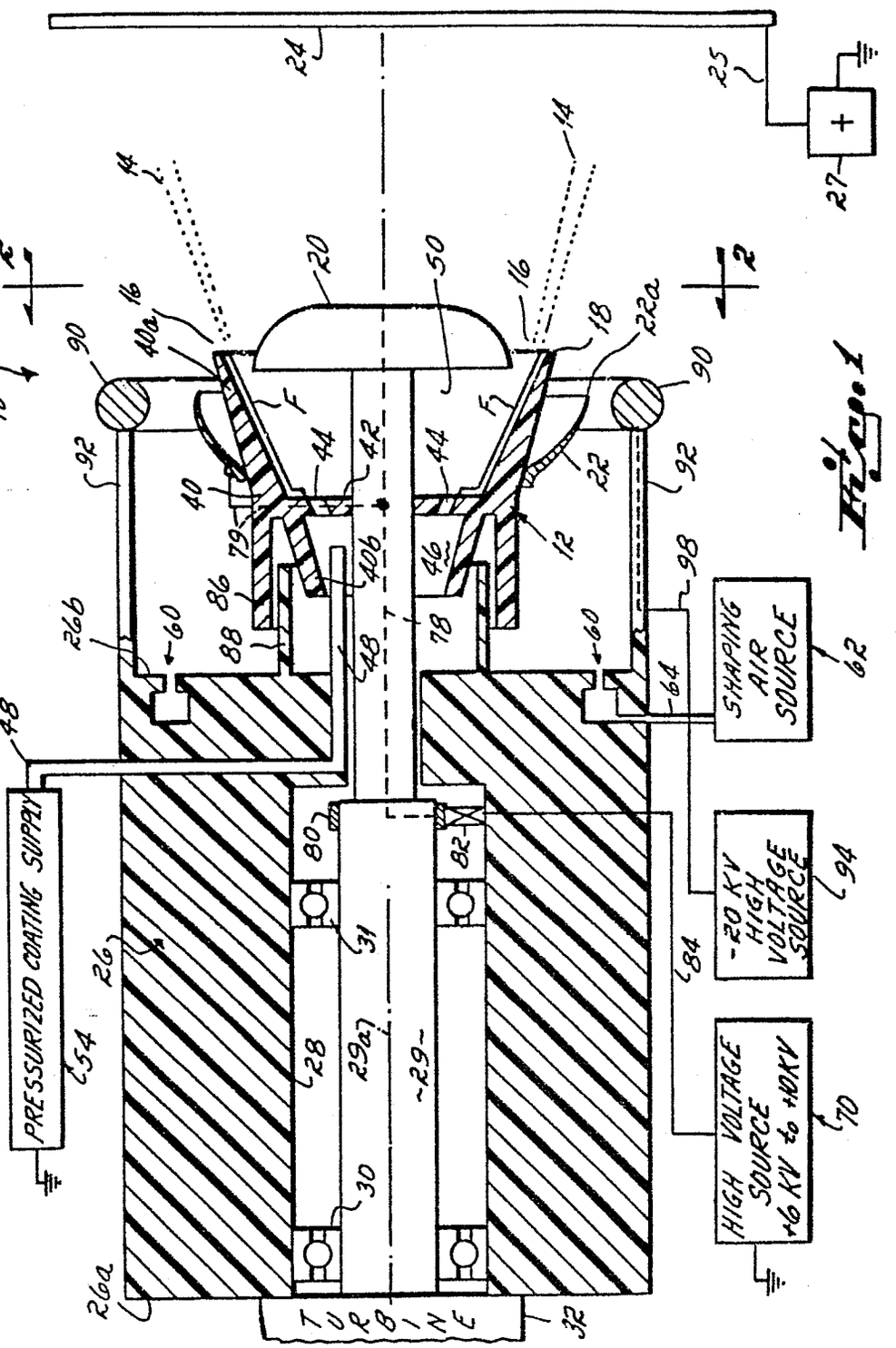

PRESSURIZED COATING SUPPLY
SHAPING AIR SOURCE
-20 KV HIGH VOLTAGE SOURCE
HIGH VOLTAGE SOURCE +6 KV to +10KV
TUBING

Fig. 1

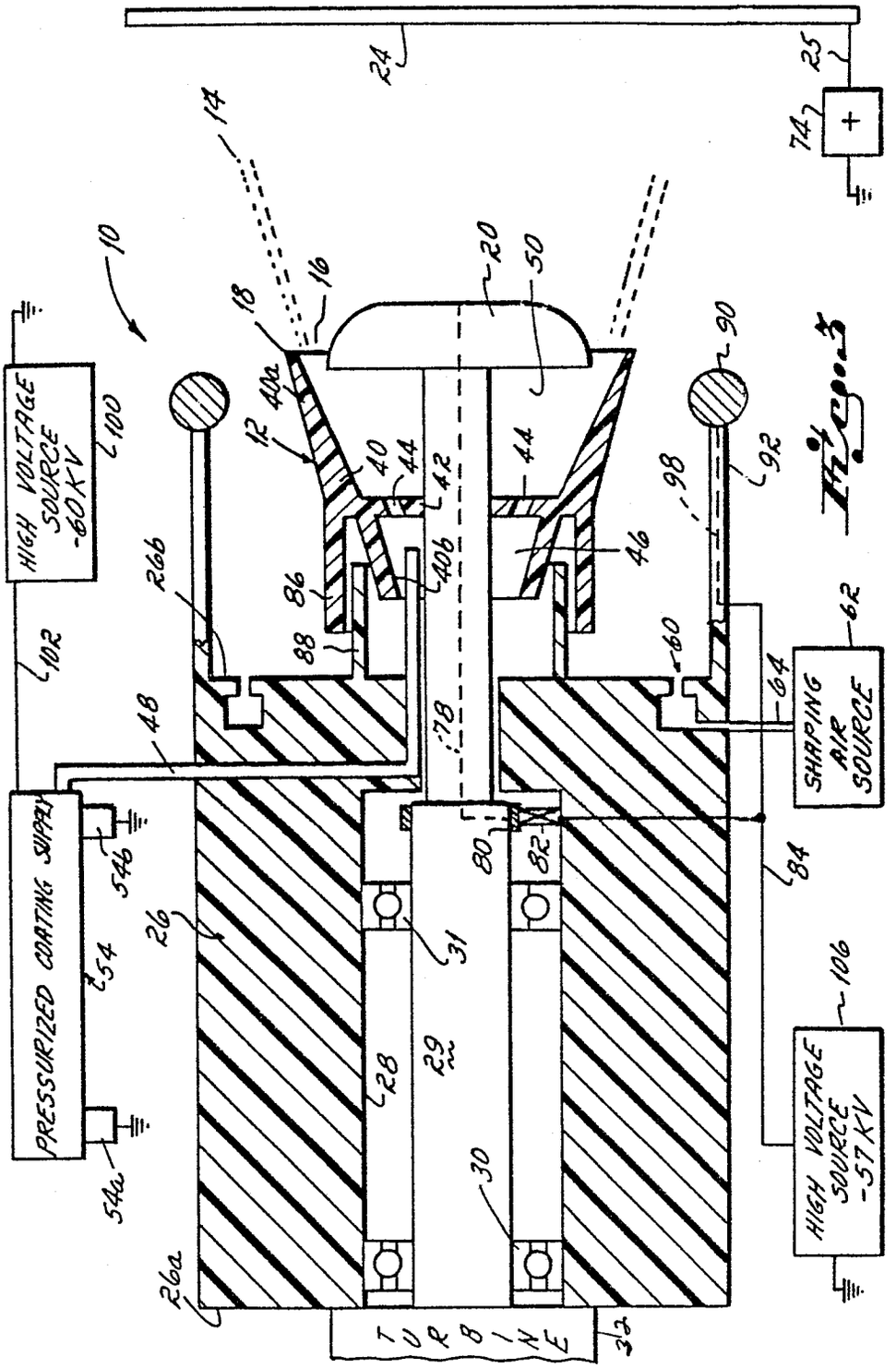

HIGH VOLTAGE SOURCE -60 KV
PRESSURIZED COATING SUPPLY
SHAPING AIR SOURCE
HIGH VOLTAGE SOURCE -57 KV
TUBING
10
12
14
16
18
20
24
25
26
26a
28
29
30
31
32
40
40a
42
44
46
48
50
54
54a
54b
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82
84
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90
92
98
100
102
106

Fig. 3

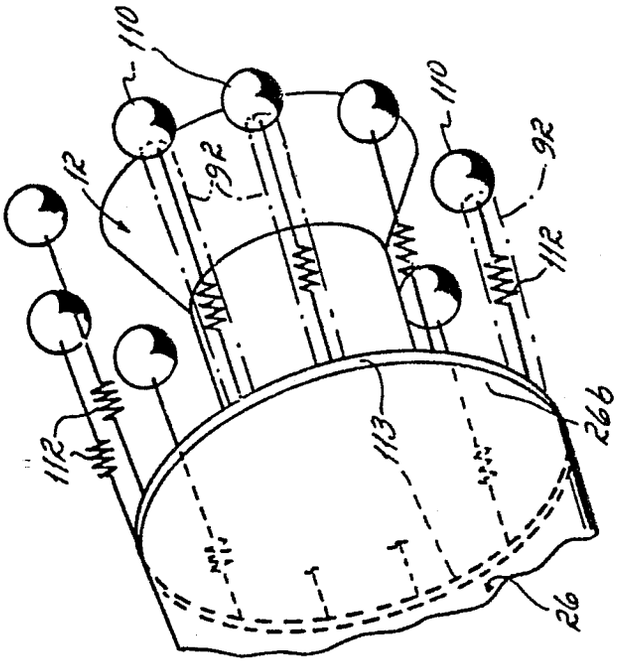

110
110
12
92
92
112
112
113
26b
26

Fig. 4

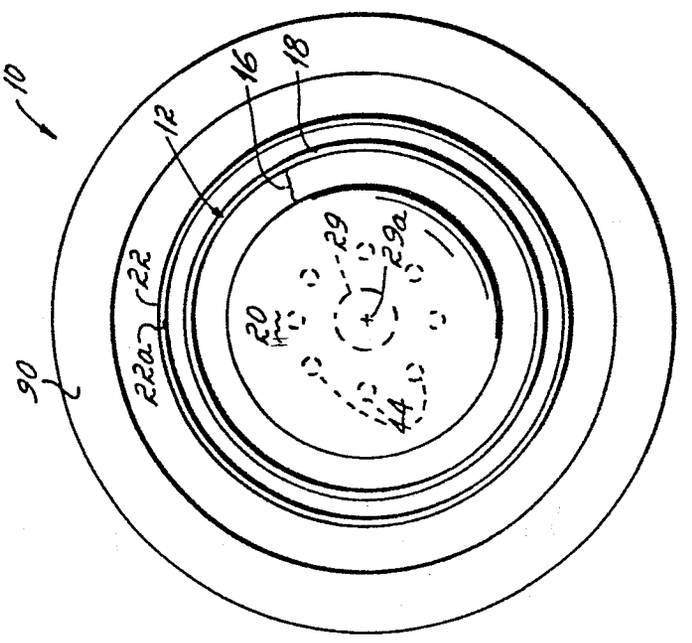

10
16
18
12
22
22a
29
29a
20
44
90

Fig. 2