

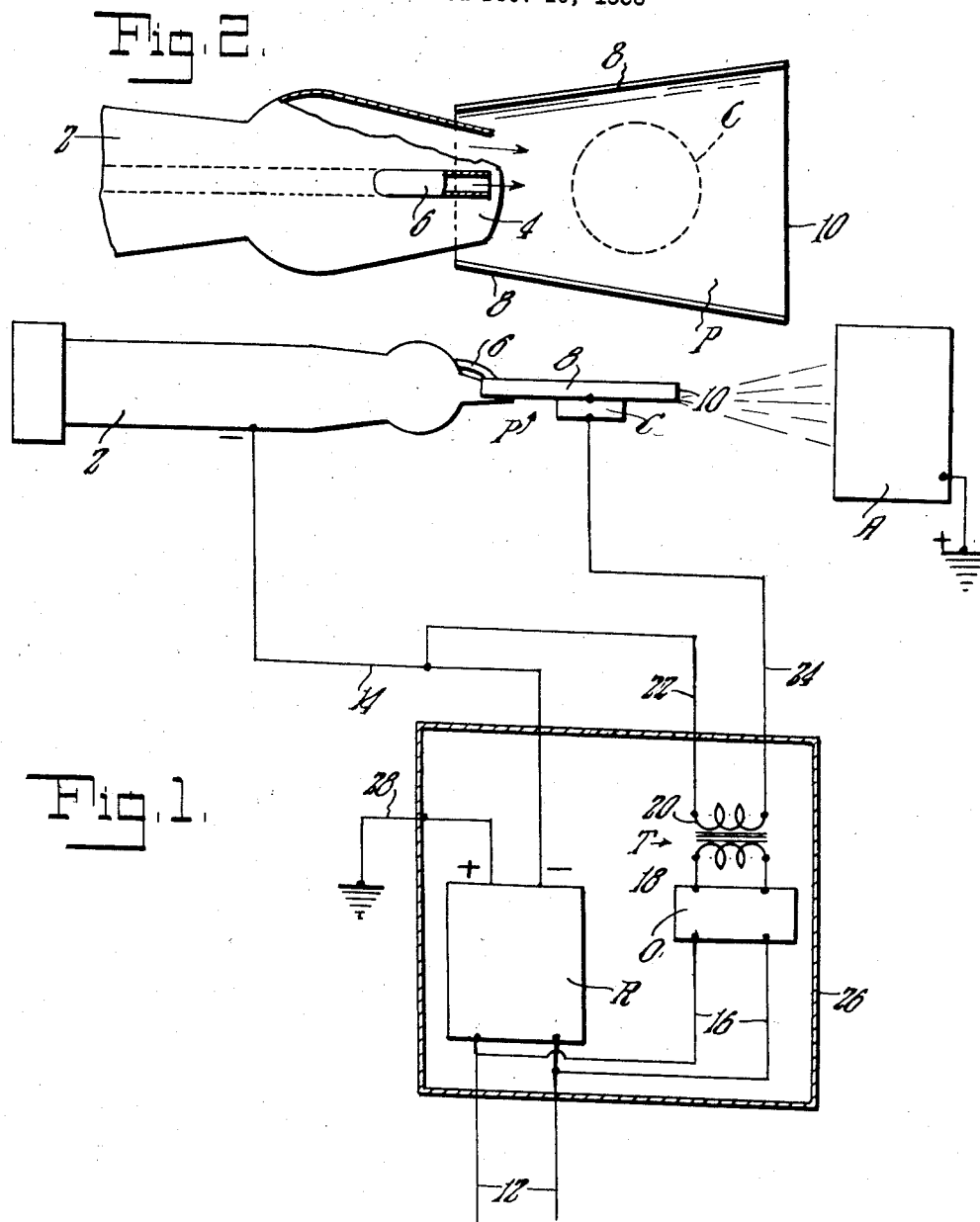
April 7, 1959

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2,881,092

SPRAY DEVICE ACTUATED BY SUPERSONIC MEANS

Filed Dec. 10, 1956



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1

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SPRAY DEVICE ACTUATED BY SUPERSONIC MEANS

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Application December 10, 1956, Serial No. 627,265

8 Claims. (Cl. 117—93)

My invention relates to improvements in an apparatus for applying a liquid coating material to an article or target by electrostatically charging and depositing the comminuted coating material upon the article or target within an electrostatic field created between the article or target to be coated and the issuing source of the coating material. That is, it relates to means for imparting an electrical charge to fluent coating materials, said electrical charge being such that when the material is atomized, precipitated, and dispersed, the charged spray is smoothly deposited upon the object toward which the atomized material is directed.

More particularly, the invention embraces means for spraying fluent coating materials by employment of supersonic vibrational waves which strike an exposed surface or film of the fluent coating material.

The invention relates to the formation of a paint spray or similar spray from a liquid material capable of relatively rapid atomization by expelling the liquid from a reservoir or issuing source in which the material is held in liquid form. This is accomplished through the use of a motive agent, such as air, in conjunction with an electrostatic attraction toward the distant article or target.

As is well known, small particles, when electrified by charges of like sign, repel one another, whereas particles of opposite sign are mutually attracted.

This invention is directed to means for improving this dispersion and deposition of the atomized particles from a charged gun mechanism upon an oppositely charged article, such means providing greater stability to the projected spray or jet and imparting a sharper edge definition to the issuing pattern.

It is now known that compressional supersonic waves from a piezo-electric quartz or other crystal exert a unidirectional pressure at the surface of a liquid. Strong supersonic motions or waves in a liquid, as the waves arrive at an exposed surface, are rectified or converted into unidirectional motions up out of the main body of the liquid, whereby supersonic waves may be used to cause unidirectional flow of liquids, which unidirectional flow may be modulated by modulating the strength of the waves.

Herein, a novel apparatus is provided for the spraying of a liquid material in a fine, mist-like jet in response to the action of supersonic vibrational waves which are caused to strike upon an exposed surface of the liquid.

A source of electrostatic high potential, having one terminal grounded and its opposite terminal connected to the atomizing head of the invention and any metallic element connected thereto, creates a strong electrostatic field between the head and the article to be coated, which article is also grounded.

Energy imparted to a liquid by ultrasonic excitation no matter how strong will not cause the liquid to break into a mist unless the "cavitation threshold" is exceeded. High electrostatic stresses on the surface of the liquid may reduce this cavitation threshold, but the cavitation process

2

produces the mist, not the compressional waves or unidirectional motion in the liquid.

The unidirectional flow in the liquid may be used to advantage as applied herein producing a mixing action so as to prevent a non-uniform distribution of paint or the like on a flat surface. In this case, it would counteract the tendency of the paint to break up under high electrostatic stress into small drops as a result of the mutual repulsion of small particles with like charges. However, concentric rings of paint would still occur at the nodal points of standing waves produced on the vibrating surface.

To produce the fine mist at cavitation levels, the high intensity of sound must be concentrated at a point or a line by some acoustical focusing device. At low ultrasonic frequencies this can be accomplished with a "horn" or velocity transformer. At high ultrasonic frequencies, the transducer can be shaped into a spherical concave surface to focus the sound at the surface of the liquid in which it is immersed.

When cavitation occurs, small vapor-filled bubbles are formed in the liquid, and as these bubbles collapse or implode, the shock-waves thus generated set up large disruptive forces at the surface, which causes the liquid to break up into a fine mist.

In this invention, the coating material is normally supplied to the discharge spout, a pan fastened thereto, and its region of corona discharge at a rate at which it can be electrically atomized by the corona discharge most efficiently and effectively, after which the charged particles are projected in spray form toward and deposited upon the oppositely charged article.

Depending upon the viscosity and other characteristics of the material, and depending also upon the rate at which the sprayer is modulated so that the unidirectional flow is accordingly modulated, the control of the supply is such as to permit the discharge of precisely the correct quantity and size of particles so as to effect the greatest efficiency in coating a surface.

These objects I accomplish by means of such structure as will fully appear by a perusal of the description which follows and by various specific features which will be hereinafter set forth in connection with the drawings wherein:

Fig. 1 is a diagrammatic view of the apparatus embodying the novel features of the invention; and

Fig. 2 is a plan view of the coating distributing plate or pan of the invention shown in association with one form of nozzle for delivering a motive agent such as air and a fluent coating material such as paint to the plate.

In this drawing, I have illustrated a complete example of one physical embodiment of the invention. It will however be understood that changes and alterations are contemplated and may be made within the scope of the claims, without departing from the basic principles of the invention.

Referring now to the drawing more in detail, in which similar characters of reference indicate corresponding parts in the several figures, and referring more particularly to the preferred form of my invention selected for illustrative purposes, I have shown a horizontally positioned nozzle, generally designated by 2. By means of the head 2 and a pan P attached thereto, the liquid coating material may be electrostatically atomized.

Such a nozzle is similar to that shown and described in an application filed by John Sedlacsik, Serial Number 468,670, on November 15, 1954.

The liquid coating material is led from a source (not shown) to the rear end of the nozzle 2 and likewise the motive agent is led from a source (not shown) to the rear end of the nozzle 2.

Said liquid coating material and motive agent are dis-

charged from the forward end of the nozzle 2 onto a plate or pan P, having a knife edge forwardly, indicated at 10.

The pan P is secured in a suitable manner to the forward end of the nozzle structure.

The nozzle is arranged so that a pair of spaced lips 4 and 4 at the forward end thereof provide a slit or mouth or opening therebetween through which the liquid coating material emerges.

The uppermost lip 4 is disposed slightly above the plane of the pan P so as to provide a somewhat wide and relatively thin stream of liquid coating material onto the rear end of the pan P.

A motive agent conducting tube 6 may be disposed within the head 2 and may extend through an appropriate opening in the wall thereof so as to provide a free outer end which may be disposed closely adjacent one of the lips 4.

In actual operation, the supply of electrical energy is fed to the high potential nozzle assembly. The coating material being atomized and the motive agent are delivered through the respective delivery tubes and connections to the head assembly and the pan. The coating material and motive agent are released in the form of high velocity streams where they meet and mix with each other under pressure and are atomized and electrically charged at the outer edge 10 of the pan, passing outwardly into the field with high turbulence.

In prior art arrangements, the projected jet wavers erratically, resulting in a scattered dispersion of the particles comprising the jet and causing the deposited pattern upon the article to have irregularly disposed lakes. In addition, the mutual electrical repulsion of the particles due to their being charged to the same sign causes them to spread and scatter laterally, particularly at the outer portions of the jet. This makes a less sharply defined edge at the boundary of the deposited pattern, than is desirable.

To overcome these objectionable characteristics, I provide a gaseous field surrounding in close proximity the electrostatic atomizing field and coextensive in length with the latter. That is, it extends along the lip with which it is substantially coaxial and terminates at the surface of the article to be coated.

In this manner, an air envelope is provided adjacent the outer periphery of the lip whereby a gaseous medium of any desired nature may be introduced around the stream of coating, being dispersed through the mouth so as to surround or envelope the same.

By the use of this gaseous envelope outside of and surrounding the liquid, the paint or other material being sprayed with the apparatus may be better concentrated or dispersed over a given area of the article being coated.

By means of this concentration of air around the liquid, the center of the area being sprayed receives as much of the sprayed material as the outer edges thereof, the air blast having the capability of directing the sprayed material inwardly toward the central area if desired.

The delivery edge 10 of the pan presents toward the articles to be coated a thinned or relatively sharp edge or discharge line, from which the coating material may be withdrawn in the form of particles, thereby aiding the electrostatic deposition.

The liquid and gaseous materials are supplied through their respective conduits to the nozzle assembly as previously described. These materials issue from their respective orifices at the outermost free end of the nozzle in the form of streams where they mix with each other. The resulting mixture is directed outwardly from the pan edge 10 with high turbulence in the form of a finely atomized stream.

In operation, a unidirectional electric potential is maintained at the high potential nozzle assembly and the pan and, as the formed stream is directed outwardly through and away from the pan, it is subjected to the

ionizing effect of the corona discharge from the pan whereby the finely divided particles comprising the spray are each imparted electrical charges of like polarity and of substantially equal potential with respect to the atomizing lips.

The positively charged particles tend to repel one another and thus resist coalescence, with the result that the electrified cloud spray is attracted to the adjacent grounded article desired to be sprayed and/or coated. The particles are attracted to and precipitate in a layer upon the nearest surface of the grounded article which is to be coated.

Coating material is urged forwardly to the discharge lips and the pan where it is electrostatically atomized and precipitated upon the article placed before the head by the action of the electrostatic field which exists between the article and the head. The particles are electrostatically dispersed as they are formed or produced along the thin line of atomization and they are electrostatically deposited while still in the liquid state upon the article surface so as to form a finished coating.

As aforesaid, the spray head and pan are connected to a source of high voltage R through one terminal thereof. The other terminal of the source is grounded and through ground is connected with the article to be coated to the end that the space or field between the spray head, pan and article to be coated is electrostatically charged.

The electrostatic forces act on the coating material, causing it to be broken up into finely divided or minute particles of coating material, so as to be attracted to the grounded article for deposition thereon.

The grounded article is referred to as a collecting electrode of one potential with the applicator head and pan serving as a discharge electrode of opposite potential.

The electrostatic forces set up in the field between the electrodes transmits the finely divided particles of the coating material from one electrode to the other.

The same action will take place when the spray head and pan are grounded and the article is directly connected with the source of high voltage and is charged at a high potential.

With voltage applied directly to the spray head structure, a corona discharge is formed in the region at the pan edge 10 and adjacent the outermost periphery thereof and is of an intensity sufficient to break up or to atomize into mist form the coating material and to project the coating material in a spray form toward the surface of the article being coated.

The pan P is formed from relatively thin metal and may have relatively diverging and forwardly extending side walls 8.

A forward transversely extending delivery edge 10 of the pan P is sharp, somewhat in the nature of a knife edge. The pan is formed from such material that it may vibrate at extremely high frequency. Particularly its terminating edge 10 should vibrate at a frequency of several thousand kilocycles.

A barium titanate or other suitable crystal C having a natural frequency of several thousand kilocycles is provided and has an upper side secured in electrical contact with the lower side of the pan P.

A rectifying power supply is represented by R for supplying direct current voltage of one hundred-thousand volts or so from an alternating voltage of conventional power lines, such as 110 to 250 volts, represented by 12.

The negative terminal of the power supply is connected by wire 14 to the nozzle 2 and thereby to the pan P, and to the lower side of a piezo electric crystal C.

An oscillator of well known form is represented by O and is connected by wires 16 to an A.C. power line.

An impedance-matching transformer is represented by T, the primary 18 of which is connected to the oscillator O. The secondary 20 of the transformer is connected by 22 to the power supply negative terminal and by wire 24 to the bottom or free side of crystal C.

A metal enclosure is represented by 26, which may enclose the power supply and oscillator and preferably these components may be submerged in oil.

The positive of the power supply R is connected by wire 28 to the enclosure 26, and to ground, as indicated.

An article to be coated is represented by A and is connected to ground, as shown.

In operation of the apparatus, oscillation of the crystal C is brought about by the oscillator connected thereto, so that the plate P is vibrated, at the same supersonic frequency.

The supersonic frequency of the crystal oscillations results in such high frequency of vibrations of the pan that coating material at the free edge thereof is broken up into a very fine mist, as distinguished from globules resulting from a spraying operation.

Alternatively to piezo-electric means for producing the supersonic energy herein employed, the magnetostrictive, electrodynamic, fluid dynamic and hydrodynamic oscillator systems could be likewise employed so as to accomplish the results herein recited.

The piezo-electric, magnetostrictive, and electrodynamic systems can actually be coupled to the device as shown. The other two aforementioned systems are means of imparting supersonic energy to the vapor or liquid phase by a jet or whistle action in the fluid or vapor, both of which systems can be used in this process.

The foregoing reveals the gist of my invention whereby others can, by applying current knowledge, readily adapt it for various applications without omitting features which, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention.

I claim:

1. Apparatus for coating an object by spraying an electrostatically charged liquid in a fine mist-like jet on said object, comprising nozzle means for projecting a mixture of the liquid and a motive agent, means for receiving the projected mixture of the liquid and motive agent from said nozzle means, said latter means being capable of supersonic vibration and having a free forward knife edge, means for supersonically vibrating said receiving means so as to apply compressional waves at a surface of the mixture of the liquid and motive agent discharged onto said receiving means, and means including a high-voltage source electrically connected, respectively, to said receiving means and to the object to be coated for maintaining an atomizing electrostatic field adjacent the free forward knife edge of said receiving means.

2. Apparatus for coating an object by spraying an electrostatically charged liquid in a fine mist-like jet on said object, comprising nozzle means for projecting a mixture of the liquid and a motive agent, pan-like means capable of supersonic vibration for receiving the projected mixture of the liquid and motive agent from said nozzle means and having a free forward knife edge, piezo-electric means for supplying supersonic vibrations to said pan-like means so as to set up compressional waves at a surface of the mixture of the liquid and motive agent discharged onto said pan-like means, and means including a high-voltage source electrically connected to said pan-like means and to the object to be coated, for maintaining an atomizing electrostatic field adjacent the free forward knife edge of said pan-like means.

3. Apparatus for coating an object by spraying an electrostatically charged liquid in a fine mist-like jet on said object comprising nozzle means for projecting a mixture of the liquid and a motive agent, pan-like means capable of supersonic vibration for receiving the projected mixture of liquid and motive agent from said nozzle means and having a free forward knife edge, magneto-

strictive means for applying supersonic vibrations to said pan-like means so as to set up compressional waves at a surface of the mixture of the liquid and motive agent discharged onto said pan-like means and means for maintaining an atomizing electrostatic field adjacent the free edge of said pan-like means.

4. A coating system including a spray gun and a knife edged pan of vibrating metal projecting forwardly therefrom, said gun being arranged to discharge a liquid and a gas on the rear of said pan, and the forward knife edge of the pan being adjacent an object to be coated, a source of high potential direct current connected between said pan and said object, a piezo electric crystal having one side fastened to the bottom of said pan, and a source of supersonic frequency electrical current connected between said pan and the other free side of said crystal whereby said pan is vibrated supersonically and an electrostatic field extends from the free knife edge of the pan towards the object to be coated, both forces cooperating to produce an extremely fine mist-like coating spray.

5. A system for spray coating an article with a liquid, including a spray gun fed with the liquid and a gaseous propellant, a vibratile metal pan attached to the discharge end of the gun so as to receive the liquid propelled thereon from the gun, and having a knife edge at the end nearest the article to be coated, a piezo electric crystal attached to the bottom of the pan, a source of supersonic frequency electrical energy connected to the crystal and a source of high voltage direct current connected, respectively, to the pan and the article to be coated, whereby the knife edge of the pan is simultaneously subjected to supersonic vibration and to corona discharge, so as to atomize the liquid when leaving the knife edge of the pan.

6. Liquid coating apparatus including a forwardly sharp-edged pan, a nozzle for spraying said liquid on said pan at a point remote from the sharp edge thereof, a source of high voltage direct current having the output thereof connected respectively to said pan and to an object to be coated with liquid, a piezo-electric transducer mounted in mechanical contact with said pan and a source of high frequency alternating current connected to the input of said transducer, whereby said liquid pan is supersonically vibrated and a simultaneous corona discharge appears at the edge thereof, so that said liquid is simultaneously atomized to a very fine mist and impelled to the object to be coated.

7. The method of liquid coating with adjuvant electrical forces, including the steps of discharging the liquid into air in the form of a thin flat film, supersonically vibrating said film, and simultaneously applying thereto a high voltage gradient in the direction of an object to be coated.

8. Liquid coating apparatus including a forwardly sharp-edged pan, nozzle means for spraying said liquid on said pan at a point remote from the sharp edge thereof, a source of high voltage direct current having the output thereof connected respectively to said pan and to an object to be coated with liquid, transducer means mounted in mechanical contact with said pan and a source of high frequency alternating current connected to the input of said transducer, whereby said liquid pan is supersonically vibrated and a simultaneous corona discharge appears at the edge thereof, so that said liquid is simultaneously atomized to a very fine mist and impelled to the object to be coated.

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