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Runstadler, Jr. et al.

[11] **3,734,406**

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[54] METHOD AND APPARATUS FOR PRODUCING A FLAT FAN PAINT SPRAY PATTERN

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[51] **Int. Cl.**.....**A01n 17/02**, B05b 7/04

[58] **Field of Search**.....239/8, 337, 366, 239/368, 414, 419, 422, 423, 424.5, 426, 428, 429, 430, 431, 432, 434, 552, 553, 590, 590.3, 596, 599, 600

[56] **References Cited**

UNITED STATES PATENTS

2,530,206	11/1950	Nieburg	239/419 X
1,500,178	7/1924	Bart	239/456 X
1,075,947	10/1913	Schurs	239/422 X
2,522,928	9/1950	Carroll	239/590.3
3,567,116	3/1971	Lindlof	239/8 X
2,297,497	9/1942	Popoff	239/424 X
2,041,482	5/1936	Paasche	239/366 X
2,351,372	6/1944	Snyder	239/414 X
2,214,035	9/1940	Tracy	239/424 X

FOREIGN PATENTS OR APPLICATIONS

1,031,287	6/1966	Great Britain	239/456
474,904	1/1915	France	239/431
19,740	3/1907	Great Britain	239/431

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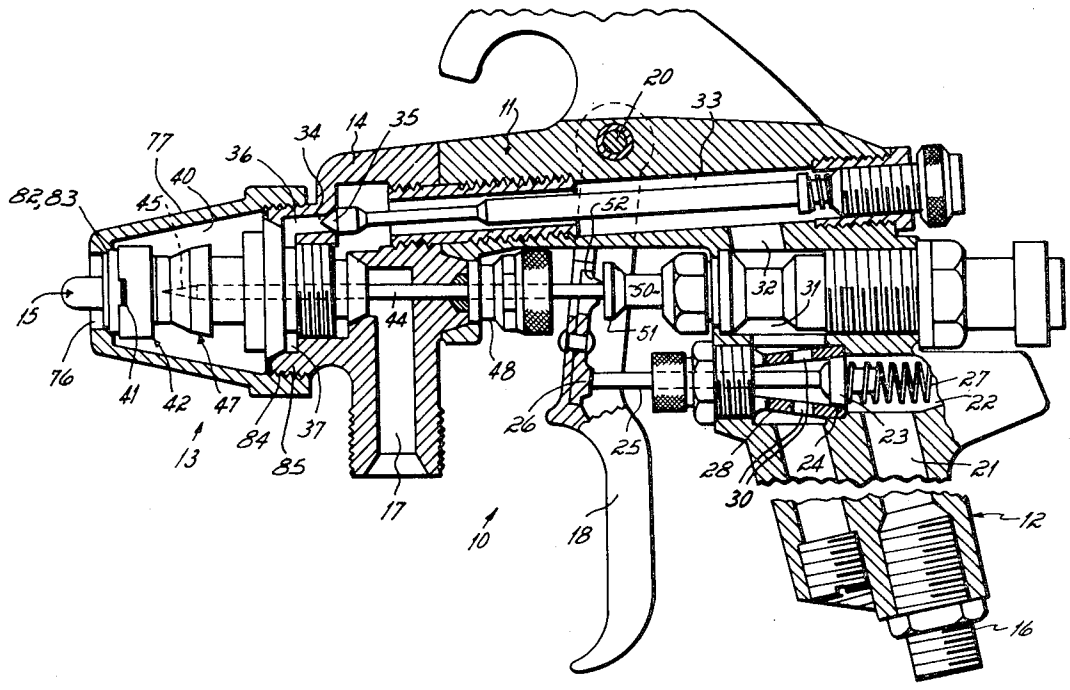
[57] **ABSTRACT**

A method and apparatus for spraying a coating material such as paint, in a flat fan pattern. In the gun a stream of paint under a relatively low pressure is caused to flow in an annular film. Streams of gas at a slightly higher pressure are directed against the paint film so that the gas is sheared into microbubbles which are entrained in the paint stream to form a froth. The froth flows through a chamber in which the bubbles disperse uniformly in the paint and is then discharged through a narrow slit nozzle effective to give it a fan shape. As the froth is released to atmospheric pressure, the microbubbles of air expand rapidly and rupture, causing the paint to disintegrate into finely atomized drops. The apparatus includes a cooperating orifice plate and collar which define a thin annular paint flow channel; and a plurality of air injection channels which intersect the paint flow channel. Air is introduced through these channels and is directed against the paint film. In the preferred gun, the nozzle includes a hemispherical endwise portion provided with an elongated discharge slot. A protuberance or ball is disposed within the nozzle and deflects the froth so that the froth passes through a relatively narrow passageway between the ball and nozzle. A modified gun includes a conventional airless flat fan orifice; and does not utilize an internal ball.

30 Claims, 10 Drawing Figures



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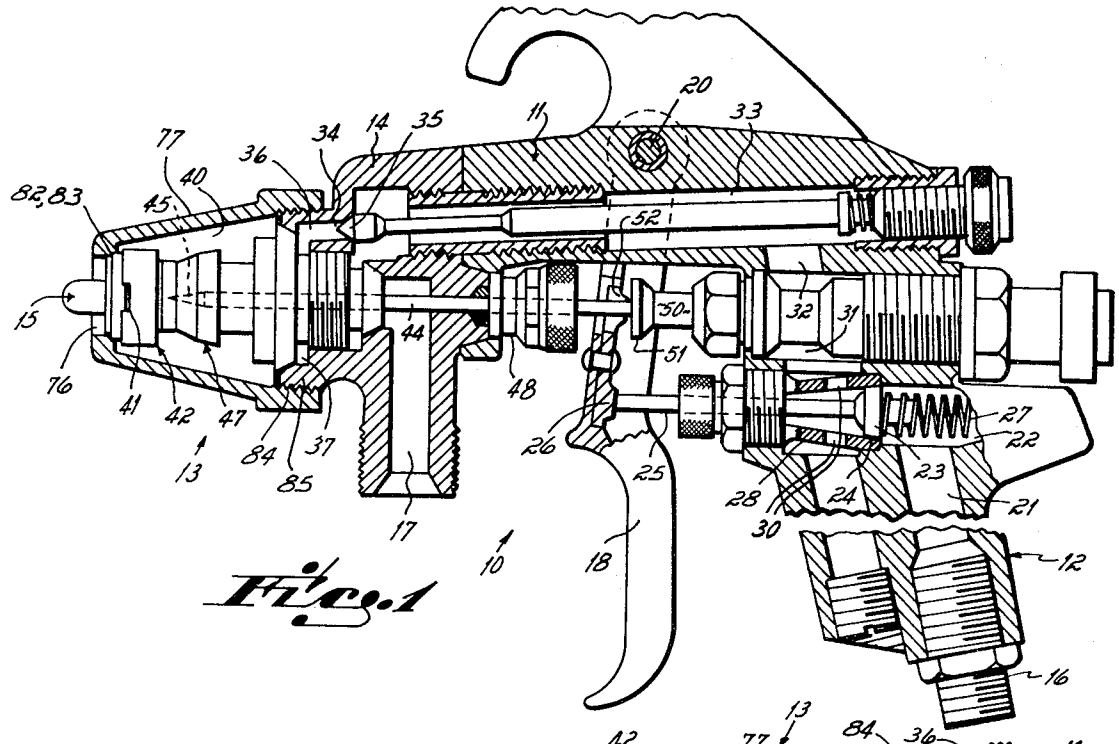

Fig. 1

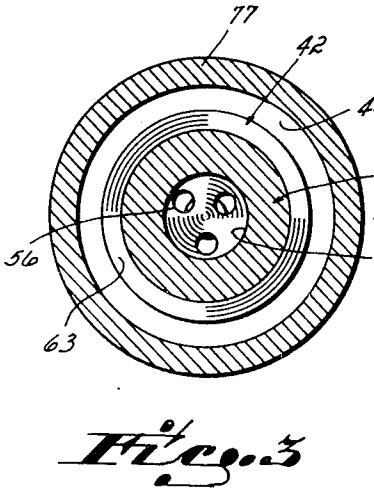

Fig. 3

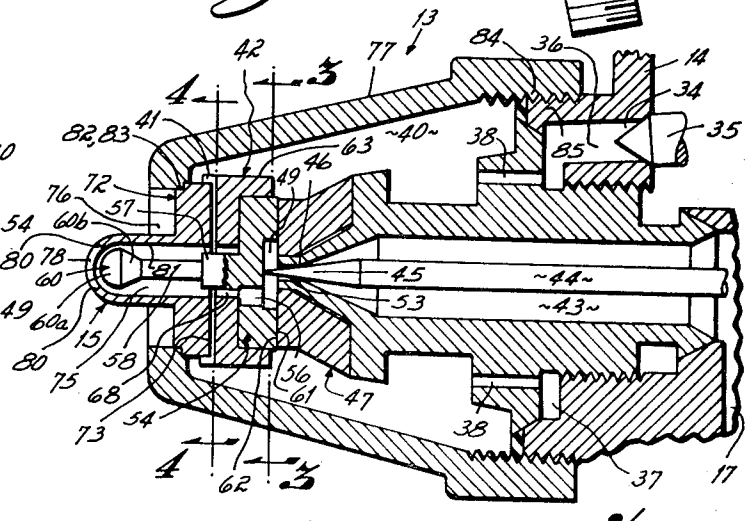

Fig. 2

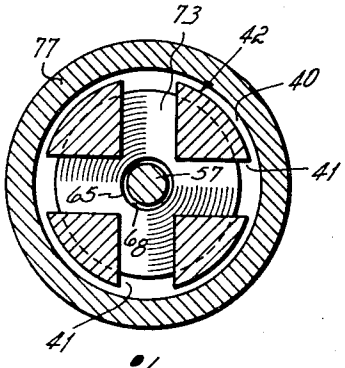

Fig. 4

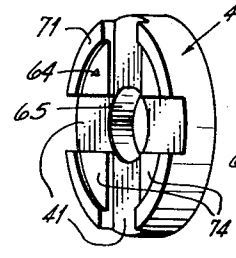

Fig. 5

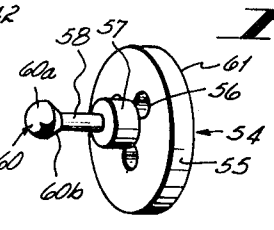

Fig. 6

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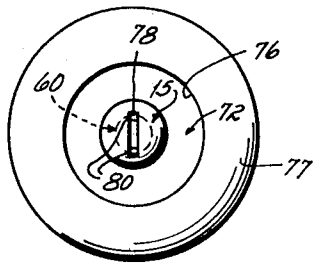

Fig. 7

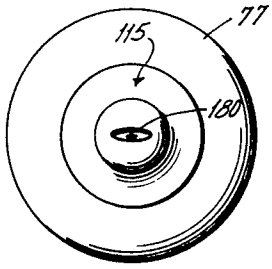

Fig. 9

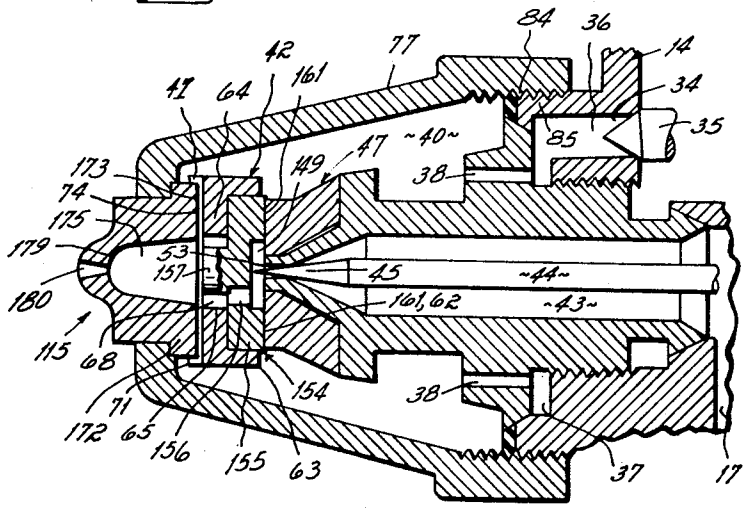

Fig. 8

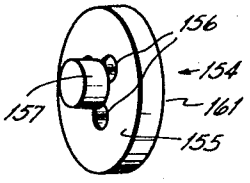

Fig. 10

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METHOD AND APPARATUS FOR PRODUCING A FLAT FAN PAINT SPRAY PATTERN

BACKGROUND OF THE INVENTION

This invention relates to a method and apparatus for spraying coating materials, such as paints, lacquers, and the like, and is particularly directed to a novel method and apparatus for obtaining a "flat fan" or narrow elongated (as opposed to conical) paint spray pattern. At the present time there are many types of painting applications in which it is desirable to form a flat fan-shaped pattern of minute spray particles. In commercial practice, this has previously been done in one of three ways.

In conventional air spraying equipment a stream of paint is extruded from a nozzle and is blasted by a stream of air under a high pressure. This high pressure air stream functions to break the rod of paint into particles. These particles are then subjected to secondary air streams which function to shape the paint spray into a flat fan-like configuration. A second known technique involves the formation of two conical sprays of paint. These conical sprays are directed against one another forwardly of the gun so that they interact to form a flat fan-like pattern. A third commonly used method in commercial practice is so-called "airless" spraying in which paint is forced through an orifice at a relatively high pressure, for example, a pressure of the order of 300–3000 pounds per square inch. In this case the orifice is of a special configuration including a small size aperture with the face of the nozzle surrounding the orifice being provided with a narrow elliptical, tapered recess to impart a fan-like pattern to the atomized paint.

Each of these methods of forming a flat paint fan has one or more inherent disadvantages. Among the disadvantages is the fact that the fan-shaped paint patterns cannot be controlled precisely to provide a uniform pattern of the desired configuration. For example, the pattern produced by an airless gun tends to have heavy tails which result in the irregular deposition of relatively large-sized droplets at the ends of the fan pattern. Similarly, with either the impinging cones or secondary air stream approach, it is not feasible to produce a uniform fan having feathered endwise portions.

The conventional air spraying method also has the recognized disadvantage that it requires a large mass of high velocity air. This high velocity air, along with the air flow which it induces, results in an objectionable wastage of paint. In the first place, an appreciable portion of the paint spray is carried past the workpiece even when an electrostatic charge is applied to the paint. Other portions of the paint spray are wasted because the high kinetic energy present in the air causes the paint to bounce back or rebound from the surface being coated.

In addition to the high paint wastage, this type of conventional air spray painting presents a substantial problem of ventilation. In many instances more than one gun is operated at a time so that it is not uncommon for a paint spray installation to be provided with a large capacity ventilation system capable of capturing paint particles entrained in a large mass of high-speed air, for example, capture velocities of 150 feet per minute. In addition, because this air carries a substantial amount of entrained paint which has been oversprayed or has rebounded, various types of filters or water curtains are required to minimize atmospheric pollution.

Airless paint spray systems also require relatively expensive equipment including pumps and related components for maintaining the paint under high pressure. Moreover, in many airless applications it is necessary or desirable to provide a heater for elevating the paint temperature to improve its application properties. All of this adds to the initial cost of the system as well as the cost of its operation.

SUMMARY OF THE INVENTION

The principal object of the present invention is to provide a completely new and different method of forming a flat spray of paint and similar coating materials. The present method and apparatus utilize a small quantity of air of the order of one-tenth that required in previous commercial air-paint spray systems so that the problem of paint rebound and overspray is very largely eliminated. The present method utilizes in part certain aspects of the method of spraying disclosed in the copending application of Peter W. Runstadler, Jr., Eric T. Nord, Donald R. Hastings, Don R. Scarbrough, and Frederick R. Wilhelm, for "Method And Apparatus For Spraying" Ser. No. 167,701 filed on even date herewith.

It is a further object of the invention to provide a novel method and apparatus for providing a flat fan of paint having markedly superior coating properties. In the first place, the paint pattern is comprised of minute particles of remarkably uniform size. These particles are distributed throughout the pattern in an extremely uniform manner. There are no tails or localized areas of paint concentration in the pattern. In addition, the pattern is particularly advantageous since its ends are feathered, i.e., are less dense. As a result, when two overlapping passes are made with the present spray, a substantially uniform coating is applied free from any heavy band effect in the area where the coating from one pass overlaps the coating from the previous pass.

It is a further object of the present invention to provide a novel method and apparatus for paint spraying which make possible the elimination of many of the expensive components of previous commercial paint spraying systems. Thus, for example, the present system can be operated from conventional shop air and does not require any special compressor for providing high pressure air as required in conventional air spraying systems. Nor does the present system utilize a high pressure paint pump or associated equipment as employed in conventional airless spraying systems.

One of the advantages of the present method and apparatus is that the paint is not only finely and uniformly atomized, but it is projected at an optimum velocity for coating purposes, for example, a velocity of 200 feet per minute at a distance of 10 inches from the gun. While this velocity is sufficiently high to cause the paint to be projected in the desired direction toward the object to be coated and to adhere to the object upon impingement, neither the velocity nor amount of air is high enough to cause more than a minimal amount of overspray or rebound. Thus, the use of the present painting apparatus and method not only minimizes paint wastage, but also greatly simplifies ventilation and filtering requirements.

More particularly, the present paint spraying method is predicated upon the concept of injecting minute air

bubbles under pressure into a confined stream of paint under a pressure of from 30–100 psi to form a froth in which the paints remains the continuous phase, passing the froth through a chamber within which the bubbles become substantially uniformly dispersed throughout the liquid, and thereafter expelling the froth through a nozzle orifice effective to impart a flat fan configuration to the resultant spray which is formed as the froth enters the atmosphere and the entrained air bubbles explode, breaking up the paint into a uniform spray of minute droplets.

In a preferred form of apparatus for carrying out the method, the paint atomizing section of the spray unit includes members configurated to form the paint stream into a thin annular film. Air injection channels are provided for directing air against portions of the film whereupon the air is sheared by the film into a series of pressurized microbubbles which are entrained in the film. The resultant froth is passed through a chamber which is configurated to provide a partial pressure drop within the froth prior to the time the froth exits through a "fan-shaping" nozzle.

In the preferred embodiment the nozzle orifice is in the form of an elongated slot in a hemispherical dome. The interior of the dome provides a chamber which houses a protuberance, having at least a segment of spherical surface concentric in a vertical plane with the interior wall of the dome and forming therewith a relatively thin curved passageway into which the froth is deflected and through which it flows prior to its emergence from the orifice.

We have determined that this construction provides a flat spray pattern having uniformly fine particle size and even distribution. In addition, the ends of the pattern are feathered so that deposited patterns can be overlapped to form a uniform surface coating.

The present invention also contemplates a modified embodiment of simpler construction for use where feathered fan edges and extreme uniformity of spray pattern are not required. This modified construction is like that just described except that no internal protuberance or ball is provided within the nozzle, and instead of a plain slot the orifice is shaped in the configuration conventionally used for airless spray. It was surprisingly determined that this nozzle provides a flat fan when spraying paint at the present low pressures in view of the fact that when paint as used in conventional airless spraying is passed through such a nozzle at these low pressures, no useful atomization whatsoever occurs.

These and other objects and advantages of the present invention will be more readily apparent from the following detailed description of the drawings illustrating a preferred embodiment of the invention.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partial vertical sectional view through one form of a spray gun constructed in accordance with the principles of the present invention.

FIG. 2 is an enlarged vertical cross-sectional view through the nozzle end of the gun.

FIG. 3 is a cross-sectional view taken along line 3—3 of FIG. 2.

FIG. 4 is an enlarged cross-sectional view taken along line 4—4 of FIG. 2.

FIG. 5 is a perspective view of the collar member.

FIG. 6 is a perspective view of the orifice plate member.

FIG. 7 is an end view of the nozzle.

FIG. 8 is a cross-sectional view similar to FIG. 4 of a modified form of gun.

FIG. 9 is an end view of the nozzle of the modified form of gun shown in FIG. 8.

FIG. 10 is a perspective view of the modified form of orifice plate utilized in the gun of FIG. 8.

DESCRIPTION OF THE INVENTION

FIG. 1 illustrates a typical spray gun **10** adapted to utilize the paint spray atomizing means of the present invention. In a typical application, spray gun **10** could be used to apply a decorative or protective coating to a product, such as a refrigerator, automobile part, furniture, containers, or the like. The coating materials to be sprayed include not only paints, but also enamels, lacquers, stains, varnishes, emulsions, waxes, adhesives and the like. For the purposes of simplifying the description of the present application, the word "paint" is used in a very generic sense to encompass all of these various types of coating materials. It is to be understood, however, that spray gun **10** is merely exemplary and the atomizing means of this invention can be incorporated in many different types of guns. For example, spray gun **10** is a hand-held, non-electrostatic gun. The present atomizing means can be incorporated advantageously in non-hand-held automatic guns of the general type shown in Juvinall U.S. Pat. No. 3,169,883.

Also, while spray gun **10** is not shown as being provided with any paint charging means, the present atomizing means can be used advantageously in connection with electrostatic spray guns having any suitable means for applying a charge to the paint spray. One generally suitable form of paint charging device is shown in Juvinall et al. U.S. Pat. No. 3,169,882. Thus, it is to be expressly understood that the details of the gun shown in FIG. 1 are shown by way of illustration and not by limitation.

More particularly, spray gun **10** includes a body portion **11**, a handle portion **12**, and a spray head portion **13** mounted on the forward end of a barrel portion **14** and having a nozzle **15** mounted at its forward end. The handle portion **12** of the gun is provided with a suitable fitting **16** for coupling the gun to an air line, for example, a shop air line under a pressure of 50 psig. The barrel portion **14** is provided with a paint inlet conduit **17**. This conduit is adapted to be connected to a paint spray line by means of any suitable coupling. It is to be understood that the paint spray line is normally fed with paint which is pumped under pressure from a paint spray tank, or alternatively, is fed from a pressurized tank. The paint pressure at the gun is relatively low and is preferably in the range of from 30 to 100 psi. This pressure is preferably regulated, or made constant, in any suitable manner.

In the gun shown, flow of paint through the gun to the spray head and flow of air through the gun is controlled by means of a trigger **18**. The trigger is pivotally mounted to the body by means of pivot pin **20**.

In the gun shown, air flows through air inlet conduit **21** to a chamber **22** which is normally closed by a valve **23** adapted to seat against a tapered annular seat **24**. Valve member **23** is carried by a stem **25** which extends forwardly from the handle into engagement with a pad **26** formed on the rear surface of trigger **18**. Valve **23**

is spring-urged to its closed position by means of a compression spring **27** disposed within chamber **22.** This spring, acting through stem **25,** is likewise effective to urge the trigger to its forwardmost position.

Tapered sleeve member **28,** which forms a seat for valve **23,** is provided with a plurality of radial passageways **30** effective, when valve **23** is unseated, to interconnect chamber **22** and, hence, air inlet conduit **21** with a passageway **31.** This passageway in turn communicates through a bore **32** to elongated passageway **33.** Air moves forwardly along this passageway through an orifice **34** controlled by a needle valve **35.** The needle valve threadably engages body **11** and is adapted to be held in its adjusted position by a conventional lock nut arrangement.

Orifice **34** communicates with a bore **36** and annular groove **37.** Annular groove **37** in turn communicates with a plurality of longitudinal passageways **38** terminating in an enlarged chamber **40.** As is explained in detail below, air is supplied from this chamber to the atomizing section of the gun through air injection slots **41** formed in collar member **42.**

Trigger member **18** also is effective to control the flow of paint to the atomizing means. More particularly, as is best shown in FIGS. **1** and **2,** paint enters the gun through paint conduit **17.** Paint flows from this conduit forwardly through a passageway **43** surrounding valve stem **44.** The valve stem is provided with a tapered end **45** adapted to seal against seat **46** formed in fluid tip member **47.** Valve stem **44** extends rearwardly through a suitable packing member **48** carried by the barrel and through an enlarged opening formed in trigger member **18.** The valve stem carries a sleeve member **50** which is slidably mounted in the gun body **11.** Sleeve **50** has a head member **51** formed adjacent to its forward end and disposed for abutment with a pad **52** formed on the rear surface of the trigger.

When trigger **18** is depressed, air valve **23** is shifted rearwardly out of engagement with tapered seat **24** so that air is free to flow from inlet conduit **21** through chamber **22,** radial ports **30,** passageway **31,** bore **32,** passageway **33** through port **34.** As the trigger is further depressed, paint needle valve **44** is shifted rearwardly so that its tapered end **45** is withdrawn from the valve seat **46** formed on tip member **47.** Thus, paint flows through paint conduit **17** and passageway **43** through the port **53** formed at the forward end of tip member **47.** In this manner, both a separate air and paint spray are admitted to the atomizing section of the gun. When trigger **18** is released, paint valve stem **44** moves forwardly to stop paint flow, and then valve **23** closes to cut off the air flow.

This section comprises an orifice plate member **54** best shown in FIGS. **5** and **6.** As there shown, the orifice plate member **54** includes a disc-like base portion **55** having three bores **56** formed therein. A cylindrical projection **57** extends forwardly of the base. This projection carries a forwardly extending support rod **58** having a ball-like protuberance **60** formed on the outer or free end thereof. More particularly, protuberance **60** includes a hemispherical outer surface **60***a* and a frustoconical section **60***b* joining section **60***a* with the support rod. The orifice plate is mounted in the gun with the rear face **61** of base member **55** in abutment with the forward face **62** of the tip member **47.** A recess **49** is formed in rear face **61** surrounding the port **53** in the tip member and interconnecting that port with bores **56.** The orifice plate member **54** is partially telescopically received within a rearwardly extending flange **63** of collar member **42.**

Collar member **42** includes a transverse wall **64** having a central bore **65** of slightly larger diameter than the diameter of cylindrical projection **57.** This bore is at least partially in registry with bores **56** and together with the outer periphery of projection **57** defines an annular film-forming flow channel **68.** Preferably this channel is between 0.005 inch and 0.050 inch in thickness.

Two diametral cross slots **70** are milled in the forward face of the collar member. These slots extend across the complete diameter of the collar member and are cut completely through a forwardly extending rim or flange **71.** In one preferred embodiment each of the slots is 0.13 inch wide and 0.015 inch deep as measured from the forward face of transverse wall **64.** In this same embodiment the diameter of projection **57** is equal to 0.120 inch while the diameter of collar opening **65** is 0.160 inch so that the annular film-forming channel **68** is 0.020 inch in width.

In this same preferred embodiment, the length of projection **57** as measured from the front face of disc member **55** is 0.125 inch as compared to a thickness of 0.109 inch of transverse wall **64.** Thus, when the collar and orifice plate are assembled as shown in FIG. **2,** the projection extends completely through opening **65** in the orifice plate and extends forwardly thereof by approximately 0.016 inch. However, this projection can terminate flush with the forward face of wall **64** or even slightly behind it if desired.

The forward face of the collar member **42** abuts circular base section **72** of nozzle member **15.** This nozzle member is centered with respect to collar member **42** by engagement of the periphery of base section **72** with the inner wall of forwardly extending flange **71** of the collar member. The rear face **73** of the nozzle base **72** engages the four quadrantal pad-like portions **74** formed on the forward face **64** of the collar member in the areas between the cross channels **70.** Thus, the base of the nozzle member cooperates with the collar to form four radial air injection channels interconnecting chamber **40** with annular paint flow passage **68.**

Nozzle member **15** further includes a forwardly extending cylindrical bore, or passage, **75** which in a preferred embodiment is 0.160 inch in diameter and approximately 0.36 inch long. The nozzle member protrudes forwardly through a central opening **76** in retaining nut **77.** The outer end of the nozzle is domed or generally hemispherical in shape (as is best shown in FIGS. **2** and **7**) and includes a generally rectangular slot **78** disposed along a diameter of the dome. As is shown in FIG. **2,** the two ends **80** of the slot are angulated so as to lie generally along radii of the periphery of the dome. The radial disposition of these edges greatly enhances the feathered configuration of the spray pattern. In the preferred embodiment the seat includes a 90° angle having its apex at the center of the dome. The innermost edges of the slot are spaced apart a distance less than the maximum diameter of ball **60** which in the preferred embodiment is 0.140 inch. Also, as there shown, the hemispherical portion of the ball is generally concentric on a vertical section with the inner wall **81** of the dome. The ball and dome thus form a hemispherical flow space approximately 0.010 inch in thickness.

The nozzle member **15**, collar **42** and orifice plate **54** are held in stacked relationship against one another and against tip member **47** by the retaining nut **77**. The forward end of this nut is provided with a recessed shoulder **82** which abuts an annular shoulder **83** formed on the forward portion of nozzle base member **72**. The opposite end of the retaining nut is provided with internal threads as at **84** for engagement with a threaded cylindrical extension **85** on barrel member **14**.

In general, the spray gun is operated in accordance with the process parameters for spraying paint set forth in the above-identified application of Peter W. Runstadler, Jr., Eric T. Nord, Donald R. Hastings, Donald R. Scarbrough and Frederick R. Wilhelm, for "Method and Apparatus for Spraying." More particularly, in the operation of the present spray gun, paint under a pressure of from 30–100 psig flows past open needle valve **44** through distributor recess **49** formed in the rear face of orifice plate **54** and through bores **56** in the orifice plate into the annular flow channel **68** formed between projection **57** and the surrounding spaced wall of the collar member. Air, under pressure, flows past the end of needle valve **35** through passageways **36** and **38** into chamber **40** and, hence, radially inwardly along four channels formed by cross slots **70**. The pressure of the air line is regulated by needle valve **35** so that the pressure of the air where it intersects the paint film is slightly greater, e.g., 2 psi greater, than the paint pressure at that area. Air emerging from the inner ends of slots **70** intersects the annular film of paint and is sheared off in the form of a myriad of entrained microbubbles in the paint. The paint, with the entrained air bubbles, then moves forwardly as a froth through chamber **75**. In this space the bubbles and paint are mixed so that the bubbles are uniformly distributed throughout the paint. In view of the fact that there is a pressure drop from annular flow channel **68** to nozzle opening **78**, it is believed that the bubbles also expand somewhat during their path of travel toward the nozzle opening.

Prior to the time that the paint and bubbles emerge from nozzle opening **78**, they are deflected outwardly in their path by protuberance **60** toward the inner wall **81** of the dome portion of the nozzle. The froth, consisting of the paint as a continuous phase and the entrained air bubbles, passes outwardly in the space between the ball and dome and emerges from slot **78**. As the froth emerges from the slot there is a sudden release of pressure to atmospheric pressure. The air bubbles in the froth expand rapidly causing the froth to be broken up into a spray of minute droplets believed to be of the order of from 10 to 100 microns in diameter. The forward velocity of these particles, 10 inches from the nozzle in a preferred embodiment, has been found to be of the order of 200 feet per minute which is ideal for spray painting.

The spray is projected from the nozzle in a flat fan pattern which is characterized by a uniform distribution of uniformly-sized particles. The pattern is particularly desirable since it has feathered edges which facilitate the application of overlapping patterns to a workpiece. The spray contains a relatively small quantity of air, for example, the mass ratio of air-to-paint is in the range of 0.1 to 1.6.

The highly advantageous results obtained from the use of the ball-like protuberance **60** are to some extent explainable only as an empirical discovery. However, it is believed that these results are due in part to the fact that the ball performs one or more of the following functions. In the first place, the ball prevents straight lineal flow from the froth-forming area to the orifice. Rather, the ball restricts the area behind the orifice and forces the froth to flow outwardly, i.e., in a transverse direction prior to the time that it reaches the orifice. In the absence of this obstruction, the liquid components of the froth would tend to accelerate more rapidly than the air, causing a non-homogeneous condition in the froth with the ultimate result that bubbles of a non-uniform size and/or distribution would be produced.

In the second place, the ball defines the inner wall of a passage, which wall is disposed to contact those portions of the paint film which have previously flowed along the inner wall of channel **68** and, hence, tend to have less air bubbles entrained therein than the portions of the film which flowed along the outer edge of the channel **68** directly adjacent to the ends of the air injection channels **70**. Because of the geometric relationship of the ball to the nozzle opening, these inner portions of froth containing less air, tend to flow adjacent to the ball, and are then forced to flow across the outer portions of froth in the nozzle area before they are emitted from the nozzle. This results in a more homogeneous mixture of the froth exiting from the nozzle and, again, results in a greater uniformity of the final bubble size and distribution.

In the third place, the ball and surrounding wall of the nozzle force the froth to flow through a confined area so that the bubbles in the froth are compacted to further increase the homogeneity of the froth, resulting in a greater uniformity of the final bubble size and distribution.

In this particular configuration, where the area of the flow path decreases from the area of air injection toward the orifice, pressure drop in the froth is enhanced as the froth flows toward the orifice. This helps the bubbles to expand, thereby further enhancing homogeneity of the froth.

While the form of spray device described above is preferred because of the very uniform, feathered-edge flat fan pattern which it provides, it is recognized that there may be applications where such an optimum pattern is not required. Accordingly, we have developed a modified and simpler form of spray gun which provides many of the advantages of the preferred form, such as the use of a small quantity of air and the production of a flat fan spray without, however, providing a pattern with feathered edges or a pattern with quite as high a degree of uniformity as that provided by the preferred embodiment. This modified embodiment is shown in FIGS. **8**, **9** and **10**. It is to be understood that all of the components of the gun, except for orifice plate **154** and nozzle member **115**, are the same as the corresponding elements of the gun in the preferred embodiment. Those elements which remain unchanged are given the same numbers in the drawings as the corresponding elements of the preferred embodiment.

More particularly, in the modification shown in FIG. **8**, orifice plate member **154** includes a disc-like base portion **155** having three bores **156** formed therein. The orifice plate further includes a cylindrical projection **157** which extends forwardly from the center portion of the base. In this modified embodiment the projection does not carry a support rod or ball. As shown,

the projection **157** is of a length such that it terminates even with the forward wall of the collar member. However, the forward end of this projection can extend beyond this forward wall in the manner of projection **57** or can terminate slightly behind the wall if desired. The orifice plate is provided with a rear face **161** which abuts forward face **62** of tip member **47.** A recess **149** is formed in rear face **161** surrounding the port **53** in the tip member. This recess provides fluid communication between port **53** and bores **156.**

A collar member **42** is disposed forwardly of orifice plate **154** and includes a rearwardly extending flange **63** which surrounds and telescopically receives the orifice plate. As in the preferred embodiment, collar member **42** includes a transverse wall **64** having a central bore **65** of slightly larger diameter than the diameter of cylindrical projection **157.** As in the preferred embodiment, the clearance between the wall of the bore and the projection is preferably of the order of 0.005 inch to 0.050 inch in width.

Two diametral cross slots **41** are milled in the forward face of the collar member at right angles to one another in the same manner shown in FIG. **5.** As explained previously, these slots extend to the periphery of the collar member and in the preferred embodiment are 0.13 inch wide and 0.015 inch deep as measured from the forward face of wall **64.**

The forward face of collar member **42** abuts the circular base section **172** of the nozzle member **115.** This nozzle member is centered with respect to collar member **42** by engagement of the periphery of base section **172** with the inner wall of forwardly extending flange **71** formed on the collar member. The rear face **173** of the nozzle engages the four approximately quadrantal pad-like portions **74** (see FIG. **5**) formed on the forward face **64** of the collar member in the areas between the cross channels **41.** Thus, the base **172** of the nozzle member **115** defines one wall of the four radial air injection channels constituted by slots **41** in the collar member. These air injection channels interconnect chamber **40** with annular paint flow passage **68.**

As is best shown in FIG. **8,** nozzle member **115** includes a slightly tapered internal passageway **175.** This passageway terminates in a rounded end portion **179.** An orifice **180** extends across the end of the nozzle member. This orifice is of the type conventionally used in airless spray equipment to provide a flat fan spray. Specifically, the orifice includes a small center aperture with the surrounding walls of the nozzle member being tapered inwardly and cut in a generally narrow elliptical-shaped opening.

The operation of the modified form of nozzle is the same as that of the preferred nozzle, except that the froth formed by the impingement of air upon the paint flows directly through chamber **175** to the nozzle opening and is not deflected outwardly by any ball member. Upon its emission from nozzle **180** the froth explodes and forms a spray having a fan-shaped pattern of minute paint spray droplets. This pattern has substantially the same air-to-paint mass ratio as that obtained from a nozzle of the preferred type. Moreover, the forward velocity of the spray is substantially the same. However, the paint spray particles are not distributed quite as uniformly hroughout the pattern and the pattern lacks the desirable feathered edges described above.

From the foregoing disclosure of the general principles of the present invention and the above description of two embodiments, those skilled in the art will readily comprehend the various modifications to which the invention is susceptible. Thus, for example, while the atomizing means has been described in relation to a paint gun, the apparatus and method also have utility in spraying other materials where a flat fan-shaped spray having a uniform drop size is desired. By way of example, the present invention also has utility in spraying various herbicides, insecticides, fuel oils and the like. Therefore, we desire to be limited only by the scope of the following claims.

Having described our invention, we claim:

1. A paint spray gun for spraying a flat fan spray, said gun having an air conduit and a paint conduit,
froth forming means including means communicating with said paint conduit and defining a film-forming channel for said paint, said channel having opposed walls, means communicating with said air conduit and including an opening in one of said walls for injecting bubbles of air from said air conduit into the paint film formed in said film-forming channel to form a froth,
a nozzle member having an orifice,
a confined space intermediate said froth-forming means and said nozzle orifice through which froth flows with the entrained air bubbles remaining under pressure, whereby when froth is discharged through the nozzle orifice the air bubbles expand to break up the paint into a spray of fine particles,
the nozzle orifice being configurated to cause the paint spray to form a flat fan pattern.

2. The paint spray gun of claim **1** in which the nozzle has a dome end and in which the orifice is a generally elongated slot in said dome.

3. The paint spray gun of claim **2** further comprising a protuberance disposed within said nozzle behind said orifice.

4. The paint spray gun of claim **3** in which said protuberance is a section of a ball.

5. The paint spray gun of claim **1** in which said orifice includes a small opening with the adjacent wall of said nozzle being cut in an inwardly tapered elliptical configuration.

6. A paint spray gun for spraying a flat fan spray, said gun comprising
a body portion,
an air conduit through said body portion,
a paint conduit through said body portion and terminating in a tip member having a paint discharge opening formed therein,
an orifice plate, said orifice plate having one face disposed toward said tip member and having a projection extending outwardly from the opposite side thereof,
a collar member having a central opening receiving said projection to define an annular film-forming channel,
said orifice plate having a bore extending therethrough to place said film-forming channel in fluid communication with the paint discharge port of said tip,
said collar member having an inwardly extending air injection channel in communication with said air conduit for injecting bubbles of air into a film of paint in said channel to produce a froth,

a nozzle having a narrow elongated orifice therein and an internal passageway therethrough in fluid communication with said film-forming chamber,

a protuberance disposed within said nozzle intermediate said orifice and said film-forming channel, whereby when the froth is discharged from the nozzle orifice the air bubbles expand to break up the paint into a spray of fine particles, said spray having a flat fan pattern.

7. The paint spray gun of claim **6** in which said protuberance is mounted on a support arm extending forwardly from said projection.

8. The paint spray gun of claim **6** in which said nozzle terminates in a hemispherical dome wall adjacent said orifice and in which said protuberance includes a portion of a spherical surface concentric in at least one plane with the wall of said dome.

9. The paint spray gun of claim **8** in which said protuberance is carried on an arm extending forwardly from said projection and in which said protuberance includes a tapered wall section joining said hemispherical section and said support arm.

10. A paint spray gun for spraying a flat fan spray, said gun comprising

a body portion,

an air conduit through said portion,

a paint conduit through said portion, said paint conduit terminating in a tip member having a paint discharge opening formed therein,

an orifice plate, said orifice plate including a transverse base portion having a rear face in engagement with said tip portion, a cylindrical projection extending forwardly of said base portion,

a collar member including a rearwardly extending flange embracing the periphery of said orifice base, and a transverse wall having a central opening receiving said projection to define an annular film-forming chamber,

the orifice plate having a bore extending therethrough to place said film-forming channel in fluid communication with the paint discharge opening of said tip,

said collar member including a forwardly projecting peripheral flange, the forward face of the transverse wall or the collar member having an inwardly projecting slot formed therein and communicating with said central opening, said slot also extending outwardly through said forwardly projecting flange,

a nozzle member having a base in abutment with the forward face of said collar member and overlying said slot to define an air injection channel,

means interconnecting the outer end of said slot with said air conduit,

said nozzle member base being telescopically received within said forwardly extending flange,

said nozzle member providing an internal passage and including a nozzle orifice, whereby when air is injected into said film of paint a froth is formed which flows outwardly through the space in said nozzle and when the froth is discharged from the nozzle orifice the air bubbles expand to break up the paint in a spray of fine particles, the nozzle orifice being configurated to spray paint to form a flat fan pattern.

11. The paint spray gun of claim **10** in which said nozzle orifice includes a small aperture and the surrounding nozzle wall is provided with an inwardly tapered elliptically-shaped recess.

12. The paint spray gun of claim **10** in which said nozzle includes a hemispherical dome wall and in which said gun further includes a protuberance disposed behind the orifice in said nozzle.

13. The paint spray gun of claim **12** in which said protuberance includes a hemispherical portion concentric in at least one plane with said dome wall.

14. The paint spray of claim **13** in which said protuberance is carried on a support member extending forwardly from said projection.

15. The paint spray gun of claim **14** in which said collar member is provided with two diametral air injection slots in its forward face.

16. The paint spray gun of claim **10** further comprising a retaining nut surrounding said tip, orifice plate, collar, and base of said nozzle member, said retaining nut defining an air chamber interconnecting the air conduit and said air injection channel.

17. The paint spray gun of claim **16** in which said retaining nut includes a shoulder engaging said nozzle member base for holding said nozzle member, collar and orifice plate in stacked relationship against said tip member.

18. A method of forming a flat fan paint spray, said method comprising the steps of

injecting a plurality of microbubbles of air into a stream of paint to form a froth,

the air and paint being intermixed as to have a mass ratio of air-to-paint of from 0.1 to 1.6,

causing said froth to flow through a confined space toward a nozzle having an orifice therein effective to impart a fan-shaped pattern to a spray, and

causing said froth to flow outwardly through said orifice whereupon the entrained bubbles expand and burst to break up said paint into a spray of fine particles having a flat fan pattern.

19. The method of claim **18** further comprising the step of causing said froth to flow transversely around a protuberance prior to its discharge from said orifice.

20. A method of forming a flat paint spray, said method comprising the steps of

forming a thin film of paint,

causing said thin film to pass transversely of an air stream directed against said film to thereby inject a plurality of microbubbles of air into the thin film to form a froth,

causing said froth to flow through a confined space toward a nozzle having an orifice therein effective to impart a fan-shaped pattern to a spray, and

causing said froth to flow outwardly through said orifice whereupon the entrained bubbles expand and burst to break up said paint into a spray of fine particles having a flat fan pattern.

21. The method of claim **20** further comprising the step of causing said froth to flow transversely around a protuberance prior to its discharge from said orifice.

22. The method of claim **20** in which the paint is formed in an annular film prior to the injection of said microbubbles of air.

23. The method of claim **21** in which said film of paint is of an annular configuration and in which the air is injected from the outside of said annulus.

24. The method of claim **23** further comprising the step of causing said froth to flow transversely around a protuberance prior to its discharge from said orifice.

25. The method of claim **20** in which the air and paint are intermixed as to have a mass ratio of air-to-paint of from 0.1 to 1.6.

26. A paint spray gun for spraying a flat fan spray, said gun comprising:

a body portion,

an air conduit through said body portion,

a paint conduit through said body portion and terminating in a paint discharge opening,

an orifice plate, said orifice plate having one face disposed toward said paint discharge opening and having a projection extending outwardly from the opposite side thereof,

a member having a central opening receiving said projection to define an annular film-forming channel,

means providing fluid communication between said film-forming channel and the paint discharge opening,

said inwardly extending air injection channel in communication with said air conduit for injecting bubbles of air into a film of paint in said channel to produce a froth,

a nozzle having a narrow elongated orifice therein and an internal passageway therethrough in fluid communication with said film-forming chamber,

a protuberance disposed within said nozzle intermediate said orifice and said film-forming channel, whereby when the froth is discharged from the nozzle orifice the air bubbles expand to break up the paint into a spray of fine particles, said spray having a flat fan pattern.

27. The paint spray gun of claim **26** in which said protuberance is mounted on a support arm extending forwardly from said projection.

28. The paint spray gun of claim **26** in which said nozzle terminates in a hemispherical dome wall adjacent said orifice and in which said protuberance includes a portion of a spherical surface concentric in at least one plane with the wall of said dome.

29. The paint spray gun of claim **28** in which said protuberance is carried on an arm extending forwardly from said projection and in which said protuberance includes a tapered wall section joining said hemispherical section and said support arm.

30. The spray gun of claim **28** in which the ends of said orifice are formed along radial lines.

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