United States Patent

[11] 3,556,411

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[45] Patented Jan. 19, 1971
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[54] **SPRAY NOZZLE**
26 Claims, 23 Drawing Figs.

[52] U.S. Cl. 239/581, 239/599
[51] Int. Cl. B05b 1/30
[50] Field of Search 239/11, 568, 590, 598, 599, 601, 543, 544, 545, 581

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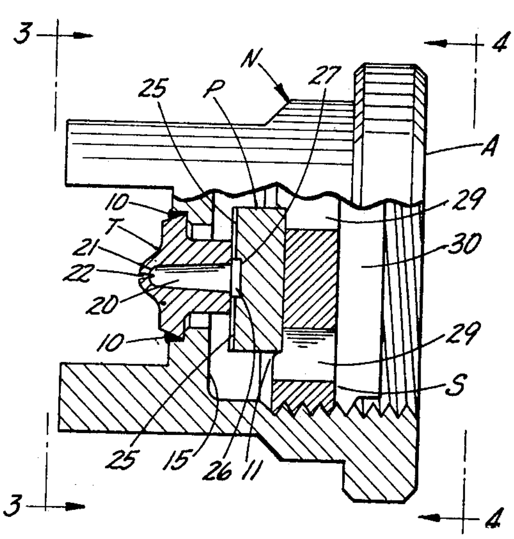
ABSTRACT: Improvements in spray nozzles suitable for hydraulic airless spraying in flat fan patterns, including spraying viscous liquids such as paint, are disclosed herein. Such an improved spray nozzle comprises a known V-cut discharge orifice in a known hemispherical or hemispheroidal impingement dome at the downstream end of a central longitudinal approach passage. It also comprises novel means at or near the upstream end of the passage in novel coaction with the downstream parts of the nozzle for giving a turbulence and/or beneficient quality to the fluid stream as it enters said dome and/or enters and flows through and/or beyond said discharge orifice. It is also disclosed that this nozzle gives an improved spray pattern with better atomization and distribution in relation to the viscosity of the fluid being sprayed and the fluid pressure drop across the nozzle. The improvements disclosed herein may also be incorporated advantageously in nozzles such as in the Brooks U.S. Pat. No. 3,366,337, for mixing and spraying two or more different constitutents of a multicomponent material system. In this improved spray nozzle, the upstream end of said passage is closed against the entry of fluid moving in the direction of the longitudinal axis of the passage, and the nozzle is free of prior art metering jets, preorifices and restrictors which tended so to move the fluid. Fluid is required to enter the upstream end of the passage transversely of said axis, and change direction abruptly with vigorous agitation in a zone or chamber of turbulence and agitation at an appreciable distance from the downstream outlet orifice. The initial agitation produces, or results in the beneficiently turbulent stream and effect mentioned above. It is also disclosed that one form of this improved nozzle is conveniently made in two parts and comprises a removable end closure part, sometimes herein called a turbulence plate, coacting with the upstream end of the said passage, which passage, with said dome and orifice, is incorporated in the other, i.e. body or "tip," part of the nozzle. The nozzle can be caused to revert to substantially prior conventional form and function upon removal of the turbulence plate from its coacting relation to and with the said tip or body portion of the nozzle.



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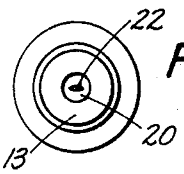

FIG. 5

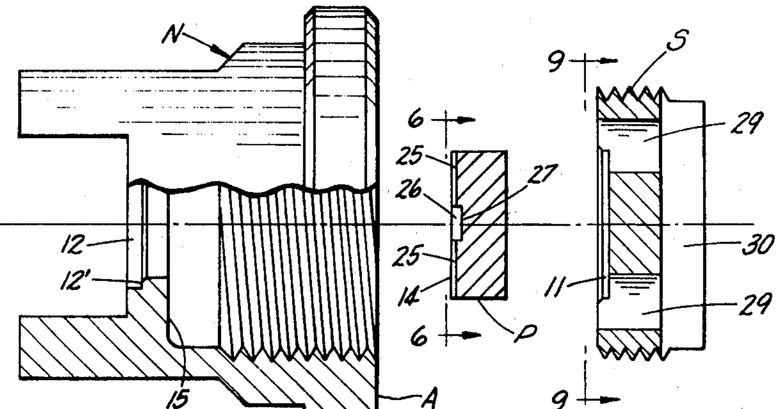

FIG. 1

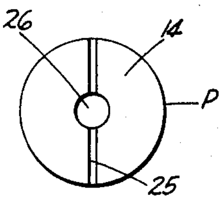

FIG. 6

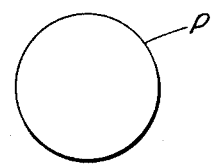

FIG. 7

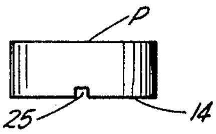

FIG. 8

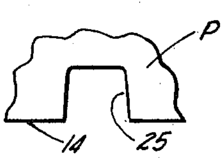

FIG. 8a

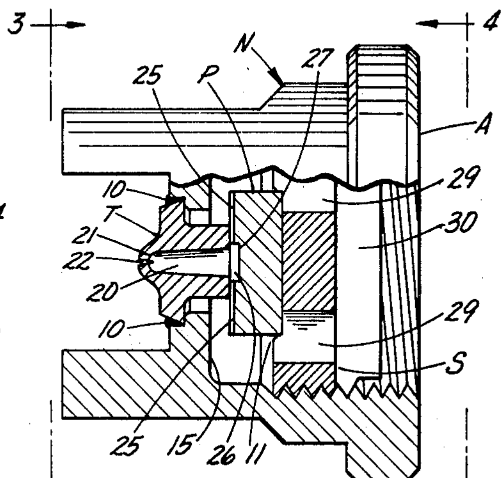

FIG. 2

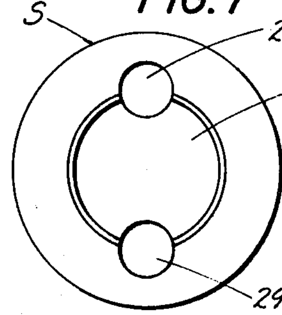

FIG. 9

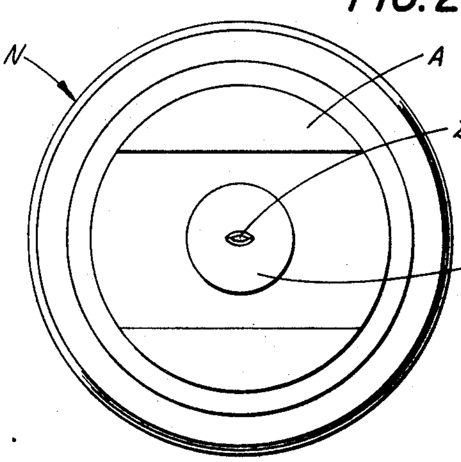

FIG. 3

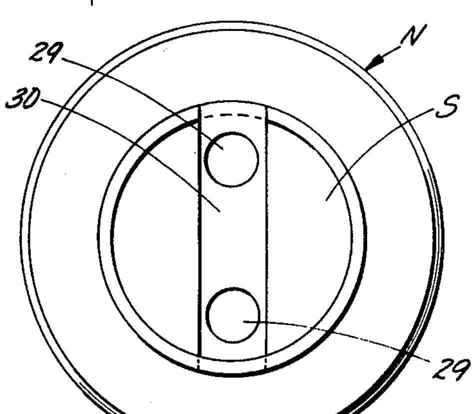

FIG. 4

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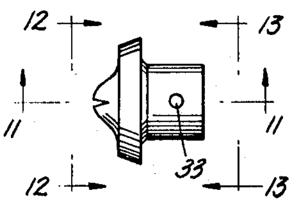

FIG. 10

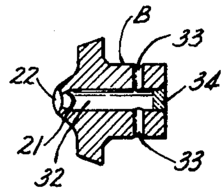

FIG. 11

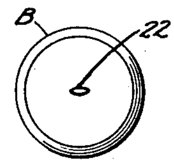

FIG. 12

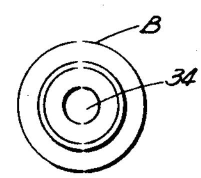

FIG. 13

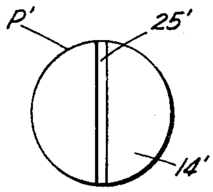

FIG. 14

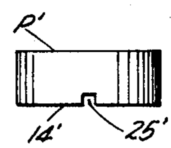

FIG. 15

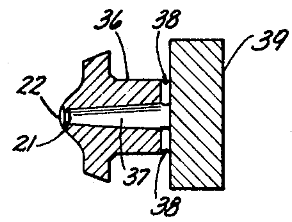

FIG. 16

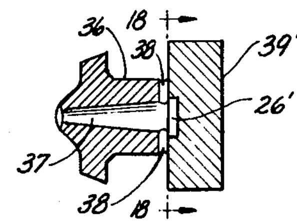

FIG. 17

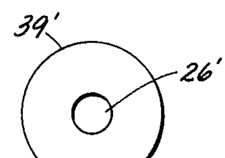

FIG. 18

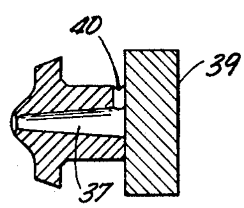

FIG. 19

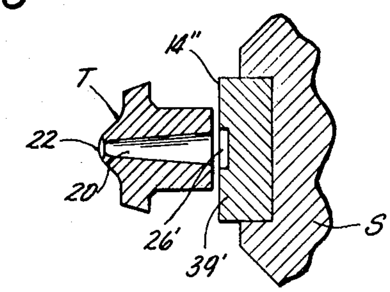

FIG. 20

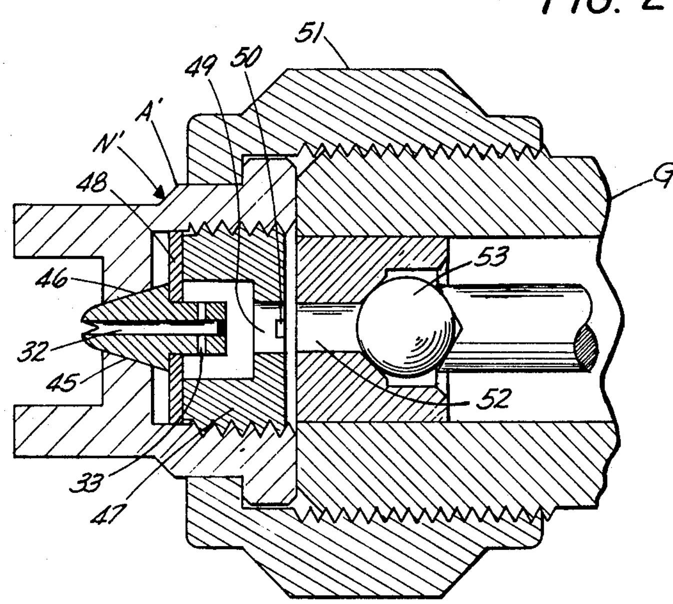

FIG. 21

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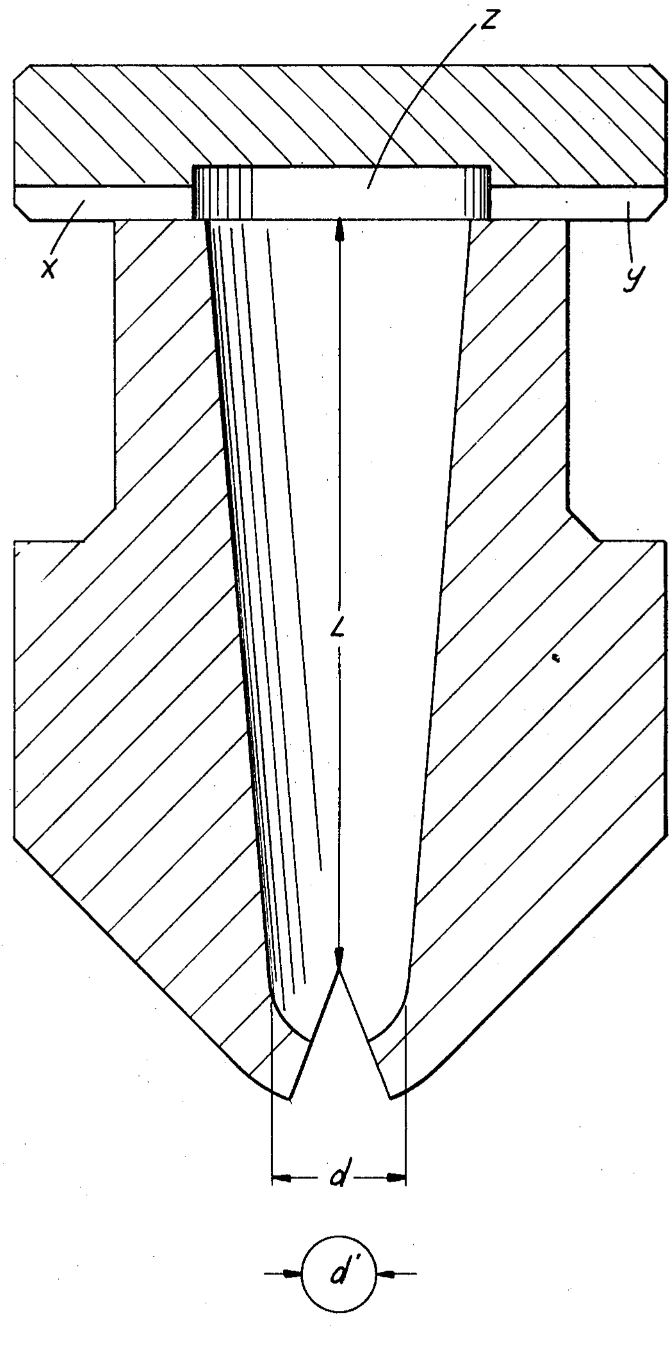

FIG. 22

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SPRAY NOZZLE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The instant invention lies in the field of Sprayers and Spraying, Nozzles—class 239 , Subclass 589 , and relates particularly to the field of spray nozzles of relatively small gallonage delivery as compared with the nozzles for lawn sprinklers and fire hoses. A particular field in which nozzles embodying this invention has especial utility, is that of hydraulic airless spraying of paint in flat fan spray patterns in which the sizes of the nozzles are such that the gallonage flow of water at 500 p.s.i. is between about 2 to 20 gallons per hour. This field also comprehends the flat fan spray pattern used in weed spraying nozzles, for example, as distinguished from the conical and swirling patterns commonly used for spraying trees and orchards.

2. Description of the Prior Art

Workers in the prior art who have sought flat fan spray patterns with nozzles of low gallonage ratings have striven and failed to gain simultaneously as compared with the best prior practices (1) fine atomization of the liquid being sprayed, (2) smooth and desireable distribution of the liquid particles across a wide spray pattern, free of tails and jetty edges, (3) low pressure drop across the nozzle, (b 4) a thin short turbulent sheet or vibrant film of liquid closely adjacent the nozzle quickly breaking into atomized particles, and (5) low velocity of the projected, atomized particles moving from the nozzle to the work, weeds or other place or target, and as a matter of fact, the prior art workers failed to gain the more desirable, or most desirable combinations of these advantageous things at the same tine and/or under the same or similar conditions. For example, in the prior art, fine atomization with desirable fan patterns has required a relatively high fluid pressure drop across the nozzle, including nozzles having metering jets and flow restrictors, in relation to the viscosity of the liquid being sprayed, The problem of accomplishing all or most of the above objectives from any and all prior relevant spray nozzles, and the different proposed means of accomplishment are exemplified, as we are presently informed, in the following patents and practices.

The Fischer U.S. Pat. No. 1,151,258 of Aug. 1915 and the Carroll U.S. Pat. No. 2,522,928 of Sept. 1950 both taught oppositely disposed intersecting transverse slots to form the nozzle orifice with a "bridge," in Fischer, and a "distributor," in Carroll, overlying the orifice and part of the upstream slot. Carroll, speaking many years after Fischer, was still striving to rid the spray pattern of "heavy edge jets" that plagued the art and characterized undesirable spray patterns then and now. The nozzles of Carroll or Fischer failed to accomplish the things mentioned above.

The Gustafsson et al. U.S. Pat. No. 2,399,182 of Apr. 30, 1946, filed in Feb. 1944, disclosed a nozzle in which a large cylindrical whirl chamber leading to a discharge orifice was provided with an upstream and closure and small tangential input passages related in cross-sectional area to the discharge orifice. The passages were widely offset to induce whirling of the fluid in the enlarged whirl chamber. Gustafsson used his nozzle for spray drying liquids in a conical spray. He was concerned with the size of spray particles for efficient drying. He employed gross swirling of the fluid entering the discharge orifice which we avoid, or convert, to produce our improved flat fan pattern.

The Munson U.S. Pat. No. 2,629,632 of Feb. 1953, filed in Oct. 1948, and the Wahlen U.S. Pat. No. 2,621,078 of Dec. 1952, filed in Mar. 1949, both disclosed the type of spray nozzle orifice characterized by a substantially hemispherical or hemispheroidal dome through which was cut a transverse slot which in its intersection with the dome formed an elliptical orifice as viewed longitudinally which was, however, curved in the spherical surface of the dome as viewed transversely. This form of orifice as taught in these patents, while not new at the date of these patents, appears to have been a much superior form of orifice than the prior orifices of Fischer and Carroll mentioned above, and, given a sufficient pressure drop across the orifice and a low enough viscosity liquid to be sprayed, produced presentable spray patterns but failed to get the simultaneous accomplishment of most or all the objectives above stated.

Munson, however, took a broad step forward in this art toward improvement of spray patterns and particularly the elimination of the "heavy edge jets " that Carroll mentioned. Munson employed a properly proportioned metering jet, or so-called preorifice, disposed coaxially and spaced upstream of the nozzle orifice with an enlarged chamber full of liquid between the jet orifice and his nozzle as shown in his patent. In his commercial exploitation of his invention known as the Marr nozzle, he matched or related the size of his jet orifices to his nozzle orifices for each different size and "gallonage " of the latter, and was able to provide uniform distribution of overlapping spray pattern especially for spraying 2—4D for weed killing. Munson's Marr nozzle still did not effect the simultaneous accomplishment of most or all the objectives above stated in comparison with our present invention.

Following the Munson improvement, the facility and advantage of the metering jet was further improved by the teaching of and practice under the Nord and Rosen U.S. Pat. No. 2,936,959, which issued May 17, 1960, on an application filed in Apr. 1956 wherein the size of the metering jet was made adjustable whereby to facilitate correlation of the size of the metering orifice to different nozzle orifices under different operating conditions. On an application filed a few years later, there appeared the Levey et al. U.S. Pat. No. 3,000,576, issued in Sept. 1961, filed Mar. 1960, which reiterated and enlarged upon the advantages and accomplishments of the Munson and Nord et al. nozzles without, however, distinguishing from or improving upon them.

BRIEF SUMMARY OF INVENTION

In structure, our preferred form is embodied in a nozzle having a conventional V-cut discharge orifice in a substantially hemispherical impingement dome at its downstream end and having an approach passage from about 4 to 10 times as long as the diameter of said dome, depending on the size of the nozzle, and axially aligned with the centers of the dome and orifice and leading thereto, and, at the upstream end of said passage having a closure against axial ingress of fluid to the passage, and preferably, having diametrically or chordally aligned, oppositely extending, lateral inlet passages of substantially equal cross-sectional area of an appreciable length, substantially radially disposed at right angles to the axis of the approach passage and having a combined cross-sectional area about the same as the equivalent area of the discharge orifice, plus about 20 percent, minus about 30 percent. The end closure has, preferably a shallow, circular, cylindrical recessed cavity opposite, and coaxial of, and substantially coincident with, the upstream end of said passage with its base wall flat and normal to the axis of the passage. This creates, with the adjacent end portion of said passage, a chamber of turmoil and zone of turbulence where the liquid inlet streams collide violently and are compelled to change direction abruptly. Other forms including but one radial inlet passage, a plurality of inlet passages directing a plurality of inlet streams into collision in the chamber and along paths not necessarily radial or chordal, and also a form having 360° of inlet passage, also embody our invention.

The function of our invention is to produce a well and finely atomized spray in a desirable wide and well distributed fan pattern moving at a relatively low velocity from the nozzle, and requiring a relatively low pressure drop across the nozzle, compared with the best known prior practices of spraying liquids of like viscosity, especially at relatively low gallonage rates of flow. That is to say, a novel function of our improved spray nozzle is to give better airless atomization in a better spray pattern, and, in the case of paint, putting the coating on the work more gently and smoothly, all with less fluid pressure drop and with the expenditure of less work and energy than has been possible according to the best prior practices with liquids of like viscosity.

The mode of operation of our invention involves the production of a great liquid turmoil with gross and minute turbulence at and in the chamber or zone of turbulence and initial agitation. As presently advised, this turbulence and turmoil comprises, firstly, turbulence of a benign character where the apparent motion of the particles of liquid are random and relatively minute and greatly diverse in direction, one from another, but all taking place within the orderly movement and desired direction of the liquid stream. Secondly, the turbulence, more especially swirling, comprises relatively great motions or streams of particles which tend to move with a deleterious effect upon the main stream, tending to give motion to the stream in its entirety, but adversely, as by giving the stream a gross and/or unpredictable spiral motion. This is different from the beneficial vigorous minute turbulence which tends to equalize the velocity in the stream adjacent the walls of the approach passage relative to the midstream velocity. The mode of operation of our invention also comprises that the approach passage serves to convert the deleterious gross motions, and preserve or enhance a uniformly forwardly moving turbulence stream with its forward velocity more nearly uniform throughout substantially its whole cross section, particularly as it enters the impingement dome and/or enters and flows through the nozzle orifice. Our mode of operation also comprises that the approach passage will not lose or dampen out the benign turbulence nor impair its desired influence and effect. It is also part of the mode of operation of our invention that the lateral input passage or passages which lead to the chamber of turbulence be of themselves long enough in relation to their cross-sectional shape and area to diminish, or substantially eliminate, gross adverse directional trends and swirls from the movement of liquid therein to the turbulence chamber. Our mode of operation also comprehends that the center of turbulence may be slightly biased with respect to the axis of the passage to give stability to the spray pattern under some conditions. It is also part of our mode of operation that the lateral input passages, where there are two of them, be diametrically aligned to lie upon the transverse diameter of the upstream approach end of the passage. The opposing streams may, alternatively, align upon a straight chord adjacent the diameter, or, for another alternative, the opposing streams may intersect and collide out of alignment in a plane transverse to the axis of and within the approach passage, wherewith to give a desirable turbulence with benign bias, but refrain from imparting deleterious and/or swirling tangential influences. When only one lateral input passage is employed, it is also within the mode of operation of our invention that the axis of such a passage lie substantially radially and intersect the axis of the approach passage, since noticeable deviations from such close intersection have been observed to give a deleterious tangential component and rotary or helical motion to the stream in the approach passage. The mode of operation of those embodiments of our invention having two or more separate input passages also comprehends and lends itself to the intimate and vigorous mixing of separate components or constituents of a multicomponent material system, such as a catalyst and a resin, for example, and spraying the mixture. That is to say, the employment of our invention in addition to the invention embodied in the gun of the Brooks et al., multicomponent gun, U.S. Pat. No. 3,366,337, will impose our mode of operation and produce our fine spray pattern and our other advantages while mixing the multiple components to boot.

The results and advantages of our invention include the substantially simultaneous accomplishment of the several desirable objectives heretofore sought but not obtained in the prior art, and incidentally and more particularly these: the thin liquid sheet which is projected from the nozzle orifice quickly disintegrates into minute liquid particles, and insures that the surface to be coated will be coated with small droplets rather than portions of the film or sheet, especially when the target must be near the nozzle. In electrostatic spraying, small liquid particles will desirably have a large charge in relation to their mass, and at the same time our invention provides that the sheet and the minutely atomized electrostatically charged spray particles have a slow forward velocity which makes it easier for the particle to be influenced electrostatically to have its direction changed and/or brought around to the backside of the work.

Another advantage of our invention is that of the low pressure drop across the nozzle which means less wear on the nozzle and greater mechanical efficiency in terms of energy expended per gallon of fluid sprayed for the same perfection of the spray quality and pattern. Another advantage is that the slowly moving spray particles impart less movement to the surrounding air which minimizes loss of spray particles which are desired to be carried to the work. Another advantage is getting smooth, even, desirable, tail-free distribution in the spray pattern and ending the need for and use of the prior metering jets, restrictors and so-called preorifices. Our invention also provides a wider fan pattern in relation to the difficult and costly narrowness of the V-cut of the nozzle discharge orifice. An object of our invention is to provide methods and means for gaining the advantages and results.

Substantially all the advantages of our invention presently appear to be realized more abundantly, the smaller the nozzle, other things being equal.

The principal objects of our invention are to promote the progress of the art in respect to solving the problems and achieving the results and advantages hereinabove set forth. Other objects include the accomplishment of these things by and within a nozzle construction of simple, uncomplicated design that can be manufactured with facility and economy in such longwearing materials as tungsten carbide, for example, and which nozzles can be readily cleaned, inspected and maintained.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is an exploded view of the constituent parts of a nozzle in longitudinal section with one part in broken longitudinal section.

FIG. **2** is a longitudinal section of the nozzle assembly comprising the parts shown separately in FIG. **1**.

FIG. **3** is an end elevation of the nozzle assembly shown in FIG. **2** taken in the plane of the line **3–3** of FIG. **2**.

FIG. **4** is an end elevation of the nozzle assembly of FIG. **2** taken in the plane of the line **4–4** of FIG. **2**.

FIG. **5** is an end elevation of the nozzle tip as viewed from the upstream end thereof in the plane of the line **5–5** of FIG. **1**.

FIG. **6** is an end elevation of the turbulence plate as viewed in the plane of the line **6–6** of FIG. **1**.

FIG. **7** is a view of the opposite face of the turbulence plate of FIG. **6**.

FIG. **8** is a side elevation of the turbulence plate with the grooved face thereof lying downwardly as viewed, and FIG. **8** *a* is an enlarged end view of the groove.

FIG. **9** is an end elevation of the perforate screw which carried the turbulence plate as viewed from the line **9–9** of FIG. **1**.

FIG. **10** is a side elevation of the one-piece nozzle tip of our invention.

FIG. **11** is a longitudinal section of the tip shown in FIG. **10** taken, however, in the plane of the line **11–11** of FIG. **10**.

FIGS. **12** and **13** are opposite end elevations of the nozzle tip shown in FIG. **10** viewed along the planes of the lines **12–12** and **13–13**, respectively.

FIG. **14** is a plan view of the grooved face of a modified form of turbulence plate, and FIG. **15** is a side elevation thereof with the grooved face disposed downwardly as viewed.

FIG. **16** is a longitudinal section of a modified form of nozzle tip and turbulence plate in their coacting relationship wherein the inlet passages are grooved into the end of the nozzle tip.

FIG. **17** is a further modification of the form shown in FIG. **16** differing from that form in the provision of a shallow, central, cylindrical cavity facing the approach passage of the nozzle tip.

FIG. **18** is a side elevation of the turbulence plate of the combination of FIG. **17** taken in the plane of the line **18–18** of FIG. **17**.

FIG. **19** is another modification of the combination of nozzle tip and turbulence plate wherein a single lateral inlet passage only is provided at the upstream end of the tip adjacent the face of the turbulence plate proximate thereto.

FIG. **20** is another modification of the nozzle tip and turbulence plate combination wherein lateral ingress into the approach passage of the nozzle tip comprises the full 360° of space between the end of the tip and the proximate face of the turbulence plate.

FIG. **21** is a fragmentary longitudinal cross-sectional view of the nozzle or forward end of a hydraulic airless spray gun with the nozzle assembly mounted thereon, wherein, however, the nozzle assembly includes the nozzle tip of FIGS. **10** to **13**, inclusive, and is removably secured and positioned within the assembled nozzle.

FIG. **22** is an enlarged diagrammatic longitudinal section of the preferred form of our invention showing the preferred proportionate relationship of the coacting functional parts and operations thereof.

DETAILED DESCRIPTION OF THE INVENTION

The nozzle N of a preferred form of our invention is disclosed in FIGS. **1** to **9**, inclusive, and comprises the conventional externally stepped internally threaded adapter A, the nozzle tip T, the turbulence plate P and the perforate screw S which has threaded engagement with the adapter A and carries the turbulence plate on its forward face for coaxially aligned engagement with the upstream end of the nozzle tip T in a plane normal to the axis of the tip, screw or nozzle adapter, as shown in FIG. **2**. In FIG. **2**, the nozzle tip T is secured in the downstream end of the adapter A as by brazing at **10**, and the turbulence plate P is brazed to and centered within a recess **11** in the screw S wherewith to be as concentric with the axis of the tip T as is practicable in view of the threaded engagement between the screw S and the adapter A. The recess **12** in the downstream end of the adapter which embraces the brazed connection between the tip and the adapter is concentric of the adapter A and the internal threads thereof. The enlarged downstream end of the tip has snug contact within the recess **12** whereby to center the axis of the tip substantially coincidently with the axis of the adapter. The tip T and the plate P are preferably made of hard, wear-resistant material, such as tungsten carbide, having in mind the velocity with which paints containing abrasive constituents move through or across these parts. The adapter and screw are made of conventional materials such as stainless steel for its resistance to corrosion and rust, as well as for the accuracy with which it may be machined and worked.

The nozzle tip T, taken alone, departs but little from conventional forms of existing nozzle tips particularly as employed in the hydraulic airless spraying of paint, except that its upstream end has a planar face **13** normal to the longitudinal axis of the tip and its central passage for tight engagement with the planar face **14** of plate P. Its principal external surfaces are cylindrical and concentric with said axis. The external upstream portion of the tip is of substantially less diameter that the adjacent hole in the adapter as shown in FIG. **2** to refrain from interference with the seating of the tip on the shoulder **12'** of the recess **12** which is also normal to the axis of the adapter and to avoid restricting the inflow of fluid to the inlet passages of the plate P. The length of the tip in relation to the internal shoulder **15** of the adapter permits free, unrestrained flow of liquid to the said inlet passages leading to the tip.

The tip T, as suggested above, has a round, slightly conical central passage **20**, hereinafter sometimes called the approach passage, the longitudinal axis of which is the axis of the tip and is aligned with the axis of revolution of the adapter and the internal threads thereof. The downstream end of the tip T preferably embraces a conventional spherical, or a slightly spheroidal, impingement dome **21** smoothly joining the downstream end of the passage **20** and having a conventional V-cut discharge orifice **22**, FIGS. **1**, **2**, **3** and **5**, giving the orifice a projected oval appearance. Such orifice sizes are known by the diameter, or area, of an equivalent circular hole determined empirically by flow measurements. The length L of the approach passage compared to its diameter *d*, see FIG. **22**, has been found satisfactory at ratios from about 4:1 to 7:1 for middle to large size nozzles and as high as 10:1 for the smaller sizes, especially for mechanical convenience. The passage may be straight cylindrical, FIGS. **11** and **21**, or tapered up to about 10° included angle as in FIGS. **2** and **22**. The interior surface of the passage **20** has conventional smoothness and texture following conventional making by pressing and sintering.

The turbulence plate P, FIGS. **1**, **2**, **6**, **7** and **8**, has aligned diametrically opposite grooves **25** cut across its forward face **14** comprising the inlet passages to the tip T when the plate has tight engagement with the end of the tip, FIG. **2**. The face **14** also comprises a central cavity **26** concentrically of the passage **20** of right, circular cylindrical form with a flat bottom wall **27** spaced from the face **14** to a depth appreciably greater than the depth of the grooves **25** up to four times the depth of said grooves. The cylindrical sidewalls of the cavity are intersected by the grooves. The cavity with the adjacent end portion of the passage **20** comprises the turbulence chamber when the nozzle is in operation. The outer cylindrical surface of the plate fits the recess **11** correctly for true centering alignment of the cavity **26** with the axis of the nozzle tip and also for facility of brazing attachment with the screw S.

As shown and suggested in FIG. **8***a*, the grooves **25** preferably approach square form in cross section, but, for convenience of manufacture, are somewhat trapezoidal with the sidewalls inclined outwardly in the direction of the open face of the groove whereby to facilitate the cutting of the grooves as with a diamond wheel. Similarly, the junctions of the sidewalls and the bottoms of the grooves are freely rounded to accommodate the cutting operation. We prefer that the total wall surface of the grooves **25**, including the opposite wall provided by the rearward planar face **13** of the tip T, have a modest to minimum ratio of wall surface to cross-sectional area consistent with the considerations mentioned above. As suggested above the combined areas of the grooves **25** is, preferably about the same as the equivalent area of the discharge orifice **22**, plus about 20 percent, minus about 30 percent.

The grooves **25** may, with advantage in a modification of this form of our invention, be not exactly equal in cross-sectional area so that the opposed inlet streams will have unequal inlet momenta and probably move or bias the center of impact or collision a little away from greatest proximity to the axis of the approach passage. It has been observed that this has, on occasion, improved the spray pattern and given stability to the form and quality of the pattern. Within the examples below, particular values for certain useful, unequal inlet passages are given.

The screw S, FIGS. **1**, **2** and **9**, carries the turbulence plate P on its forward, downstream face for aligned forcible engagement with the upstream end of the nozzle tip as shown in FIG. **2**. The screw S has external threaded engagement with the internal threads in the adapter A as shown in FIG. **2**, whereby to press the plate into firm, tight sealing contact with the end of the nozzle tip whereby to give the grooves **25** the function of exclusive inlet passages. It should be noted, however, with reference to FIG. **20**, that the screw S may also perform the office of holding the forward face of the turbulence plate an adjustable and desired axial distance away from the adjacent end of the nozzle tip, as well as making forcible contact therewith as will be more fully described in relation to FIG. **20**. Characteristic of the screw S are the relatively large longitudinally extending holes **29** which provide free low velocity flow of fluid from the main valve of the paint or other spray gun, see FIG. **2**, to the nozzle tip and/or plate. Two such holes are shown. As many may be provided as may be necessary or convenient to provide an adequate supply of fluid or liquid to be sprayed to the lateral inlet passages of the nozzle. A transverse slot **30** at the upstream side of the screw S may be provided for reception of the end of a screw driver, wherewith to twist the screw in its threaded engagement with the adapter.

Another form of our invention is illustrated in FIGS. **10** to **13**, inclusive, and comprises an entire nozzle made in one integral piece rather than in the tip-and-plate form described above. In this, the one-piece form, the nozzle tip also comprises the body and will be called the tip of body B. This form may embrace the same impingement dome **21** and V-cut outlet orifice **22** as employed in the tip T, but the approach passage **32** in this form is substantially cylindrical throughout its length consistent with a minimum "draft" to facilitate manufacture. Inlet passages **33**, oppositely aligned, preferably diametrically, are cross-drilled at right angles to the approach passage and spaced from the dome **21** preferably about 4 to 7 times the diameter of the passage **32**. The combined area of the inlet passages is preferably about the same as the equivalent area of the orifice **22** plus or minus about 25 percent.

The passage **32** is, in the first instance, formed throughout the entire length of the tip B, and thereafter, is closed as by an epoxy resin plug **34** first intruded in plastic form to close the zone of turbulence at the intersection of the passages **32** and **33**. The resin will set symmetrically with respect to the axis of the passage while the passage stands upwardly above the resin. Externally, the tip B may be the same as the tip T and may be permanently secured in the recess **12–12'** of the adapter A in the same way that the tip T is secured, cf. FIG. **21**. When this form of our nozzle tip is employed in the adapter A, the screw S and turbulence plate P of the preferred form of our invention may be removed. Alternatively the plug **34** may be omitted, and the open end of the passage **32** closed by a turbulence plate **39**, FIG. **16**, coacting with the end of the tip B in the same way that the plate **39** coacts with the end of the tip **36** in FIG. **16**. Another alternative which we believe has better advantage in larger nozzles and/or with tapered approach passages, comprises that the end of the passage **32**, whether in cylindrical or slightly conical form, be "closed" by either the turbulence plates P or P' coacting with the end of the tip B as those plates coact with the end of the tip T in FIG. **2**. This provides an axial as well as radial plurality of inlet passages, preferably of similar size and of total area like the equivalent area of the orifice **22** plus or minus about 25—30 percent.

A modification of the preferred form of our invention, FIGS. **1** to **9**, inclusive, is illustrated in FIGS. **14** and **15** and comprises a turbulence plate P' corresponding entirely with the turbulence plate P except that it lacks the cavity **26** and extends the groove **25'** continuously across the downstream face **14'** of the plate. The groove **25'** is straight and continuous and preferably lying in a diameter of the plate P'. The midportion of the groove **25'** with the adjacent portion of the approach passage **20** will comprise the turbulence chamber in this modified form of our invention. This modification of the downstream aspect of the turbulence plate avoids the need or desire for aligning the recess cavity **26** with the end of the passage **20**, and permits the incorporation of a little benign bias where the probable center of the point of collision of the oppositely entering inlet streams lies a little to one side of the axis of the passage **20**, whereby to give a stability to the spray pattern without jeopardizing the character of the stream flowing downwardly in the passage from the zone of turbulence to the dome of impingement. The bias herein contemplated does not have a deleterious tangential aspect tending to cause the stream to swirl in its motion toward the discharge orifice of the nozzle.

Another modified form of our invention is shown in FIG. **16**. Here the nozzle tip **36** may take the interior and exterior form, size, and proportion corresponding to either of the corresponding parts or portions embraced in the tips T and/or B above described from the impingement dome **21** and outlet orifice **22** up to the chamber of turbulence where the inlet passages intersect the approach passage **37**. In this form of our invention, the inlet passages **38** substantially correspond to the inlet passages **25** of FIGS. **6**, **8** and **8***a* except that they are cut in the upstream end of the tip **36** rather than in the face **14** of the turbulence plate P. The passages **38** are diametrically opposed with their axes intersecting the axis of the passage **37** at right angles, and preferably have the same relation and size of cross-sectional area to the equivalent area of the outlet orifice that the inlet passages **25** have to the equivalent area of the outlet orifice. In this form of our invention, the turbulence plate **39** has its forwardly facing surface plain and continuous and planar, substantially the same as its rearward face as shown in FIG. **7**, whereby to close the end of the passage **37** and close the open sides of the grooved passages **38** when the plate **39** is forcibly pressed against the upstream end of the nozzle tip **36** by the means and in the manner described in relation to the turbulence plate P of the preferred form of our invention.

The modified form of our invention illustrated in FIGS. **17** and **18** embraces the nozzle tip **36** just above described for the purpose of illustration and may otherwise be substantially identical with the tip and plate assembly shown in FIG. **16** with the exception that the turbulence plate **39'** has a cavity **26'** substantially corresponding to the cavity **26** of the turbulence plate P formed in the forward aspect thereof coaxial with the passage **37** and substantially coincident with the upstream end thereof whereby to form a chamber of turbulence with the upstream end of the passage **37** at and about the place of intersection of the transverse inlet grooves **38**. As in the case of the cavity **26** in relation to the passage **20** of the tip T, we prefer that the diameter of the cavity **26'** be slightly greater than the diameter of the upstream end of the passage **37** to permit the cavity **26'** to overlie the circular end of the passage **37** when the longitudinal axis of the cavity **26'** is not strictly aligned with the axis of the passage **37**.

The modified form of our invention shown in FIG. **19** is the same as the form of FIG. **16** in all respects except that the nozzle tip or body has but one lateral inlet **40** instead of the pair of inlets **38**. The inlet **40** has about the same area as the combined areas of the passages **38**, i.e. about the same as the equivalent area of the discharge orifice plus about 20 percent, minus about 30 percent. The axis of the inlet **40** is radial and is intended to intersect the axis of the approach passage **37** at a right angle with substantial accuracy to avoid giving a tangential swirling component to the stream in the approach passage. The inlet stream coming through the inlet **40** smashes against the opposite wall or surface of the approach passage **37** and sets up a violent benign turbulence in the zone about and adjacent the place of intersection of the axes of the passages **37** and **40**. The single inlet **40** may well take the general cross-sectional form of the passages **25** of FIG. **8***a*. An advantage of the single inlet form is that it may have a cross-sectional area significantly larger than the solid, insoluble and/or pigment particles carried in the liquid or fluid stream and avoid clogging that might occur in either of a pair or any greater number of smaller inlet passages or paths. The single inlet exemplifies an extreme biased condition that is advantageous so long as the axes of the streams intersect and/or don't set up an adverse swirl.

The last mentioned contingency suggests a potential limitation in the modification illustrated in FIG. **20** where lateral fluid entry to the nozzle tip T is effected in the 360° of annular space between the flat annular upstream end of the tip and the juxtaposed flat forward face **14''** of the turbulence plate **39'**. The plate **14''** has a central cavity **26'** aligned with the axis of the approach passage **20** of the tip T. When the distance between the said proximate flat parallel faces of the tip and plate is one-fourth the diameter of the adjacent end of the passage 20, the rate and velocity of flow of inlet fluid to the turbulence chamber at the upstream end of the passage 20 and cavity 26' will substantially equal the rate and average axial velocity of flow from the chamber. This relationship gave good results in a tested embodiment using, however, a non-recessed turbulence plate like the plate 30, and a cylindrical approach passage as in the tip B short of the inlets 33, in a size having an equivalent orifice diameter of about 0.016" and having an equivalent orifice area of about two-thirds to three-quarters the area of the annular inlet opening at and to the chamber. This spacing of the plate from the tip tested the upper limit of our preferred relationship between inlet area and equivalent orifice area stated for other forms of our invention. Here the distance between the tip and the plate was only about 0.004" to 0.005" which we feared might filter pigments or other solid particles out of paint or other fluids. For clear liquids this and lesser spacings as in smaller nozzles will not limit the utility of this form of our invention nor suggest or require substantial departure from our preferred relationship between inlet and effective orifice areas. In larger sizes and/or with tapered approach passages and/or recessed plates, FIG. 20, our preferred inlet to effective orifice area relationship presents no deleterious filtering problem and is therefore affirmed, without teaching, however, to avoid any relationships that selective adjustment of the distance between the plate and tip may discover for particular fluids or other operating conditions. In all variants and sizes of this form of our invention the convenience and advantage of adjusting the distance between the plate and the tip by twisting the screw S in the threads of the adapter is obtained. A snug fit in the threads suggests itself as a convenient means for holding a selected adjustment.

When the tip B with the permanent plug closure 34 is fixedly attached in the adapter A, the facility of cleaning the tip is restricted for lack of access, especially in low gallonage sizes. To facilitate access to the tip B, or any other tip, it may be removably positioned and secured in the adapter A' of the nozzle assembly N' as shown and suggested in FIG. 21. Here, the adapter, otherwise like the adapter A, has a conical female seat 45 complementary to the conical male exterior surface 46 of the tip providing a tight sealing engagement when the tip is forcibly seated by advancing the screw 47 in its threaded engagement with the internal threads of the adapter as shown in FIG. 21. A washer 48 spans the end of the screw and the adjacent shoulder of the tip to open space for fluid to reach and enter the lateral inlet ports 33. The screw 47 with a screw driver slot 50 has a large central opening 49 for the free, easy flow of fluid to the tip. This removable attachment of the tip not only facilitates removal of the tip for cleaning and inspection but facilitates replacement and selective employment of tips of varied capacities and forms without other changes of the adapter and screw assembly.

Fig. 21 also illustrates a connection between a nozzle assembly and the front end of a hydraulic spray gun, such as a high pressure hydraulic airless paint spray gun illustrated in Rosen and Nord U.S. Pat. No. 3,116,020, absent the restrictor plate therein specifically illustrated. Particularly the front end of the gun G has external threads wherewith the internally threaded nut 51 secures the nozzle assembly N' in fluidtight contact with the end of the gun. The gun has a large fluid passage 52 leading from the large, fast opening and closing valve 53 as shown and described in said patent.

The following examples of comparative operations and results of different specific forms and sizes of embodiments of our invention are intended to amplify and clarify our teaching. Reference will be made to the enlarged view of tip and plate in FIG. 22 where the length L of the approach passage is measured from the center of the impingement dome to the upstream end of the tip, and the diameter of the dome *d* and adjacent approach passage is shown for comparison with the diameter *d'* of the equivalent circular area of the outlet orifice. The passages *x* and *y*, corresponding to the inlet passages 25, 25', 33, 36 etc. and the cavity Z corresponding to the recesses 26, 26' and at 34 are also indicated. In the following examples in which the nozzle tips according to FIGS. 10 to 13 inclusive and FIG. 21 were employed the inlet areas were those of the passages 33, the diameter *d* and *d'* were the same as those indicated in FIG. 22 and the approach passages were substantially straight cylindrical rather than slightly conical as illustrated in FIG. 22, and the length L is measured from the center of the dome to the nearest side of the inlet passages 33.

In the following examples the comparative tests were made with nozzles of gallonage ratings established and published by the assignee of this invention based on the flow of water in gallons per minute through the V-cut orifice in a conventional nozzle tip at 500 p.s.i. pressure drop thereacross. The following tabulation shows these gallonage ratings covering the range of sizes of nozzles tested and the values for *d* and *d'*, FIG. 22, in each size:

Flow in gallons per minute at 500 p.s.i.	d' in inches approx.	d in inches approx.
.03	.007	.010
.04	.009	.011
.06	.011	.013
.09	.013	.016
.14	.016	.020
.20	.020	.025
.30	.024	.031

The preferred relation of length to diameter of the approach passages, whether substantially cylindrical or slightly tapered, L/*d* FIG. 22, according to our best present understanding, not only requires length per se in the smaller sizes to relate and adapt the tips and bodies T and B to the adapters and turbulence plates with mechanical convenience, but also a high L/*d* ratio such as 10:1 performs the desirable function especially in small nozzles, of converting adverse swirl to benign turbulent flow to the nozzle orifice. High L/*d* ratios, however, especially in larger nozzles, tend to have the adverse effects of dampening out benign turbulence and/or requiring more pressure drop to gain or preserve it than we have found necessary with lower L/*d* ratios. The following examples will illustrate and test our preferences as to certain L/*d* ratios, among other things.

In the following examples, nozzles embodying our invention were attached to commercial Nordson airless paint spray guns following said Nord and Rosen U.S. Pat. No. 3,116,020 with the restrictor disc therein illustrated, removed. When our nozzles took two-piece form, FIG. 2 for example, comparison was made against the same gun and nozzle tip with our screw S and turbulence plate removed, and the said restrictor returned to the gun between the nozzle assembly N and the end of the nozzle as shown in said patent. Such restrictors followed Nordson's prior commercial practice and had a central hole aligned with the axis of the tip and of diameter specified in each example below. The holes in these restrictors were of shorter length than diameter. When our nozzles took one-piece form, FIGS. 10—13 for example, they were attached to the same guns with restrictors removed, and compared with Nordson prior art tips, which had open upstream ends and no lateral inlet passages 33, in the same guns with the restrictors restored.

Example I

A nozzle of the form shown in FIGS. 1 and 2 with a tip T, but having a turbulence plate P' of FIGS. 14 and 15 and of 0.03 gallons capacity as measured and tabulated above, and having corresponding equivalent orifice area and diameters *d* and *d'* above specified, and a ratio of L/*d* of 10:1, and inlet passages of equal *x* and *y* areas which combined to be substantially equal to the equivalent nozzle area, was compared with the same nozzle tip in the same gun under the same conditions, but employing a restrictor with a 0.010 inch diameter orifice; the screw S and turbulence plate being removed. In both instances, an alkyd baking enamel was sprayed at 150° F.

at the gun with a viscosity of 27 centipoise and with the spray fan horizontal. In both instances, enough paint was sprayed onto a sheet of corrugated paper with its corrugations disposed vertically to deposit a central painted area in which the paint ran down the corrugations a distance approximately equal to the width of that area. The test of the presence or absence of tail formations, or jetty edges, in distinctly separate areas beyond the ends of the central area comprised, at the lower limit, noting the spraying pressure at which the quantity of liquid paint deposited in the tail area was sufficient to just begin running down one of the corrugations. This condition is designated arbitrarily as the threshold of running tails. The upper limit of spraying pressure was noted when the last least noticeable deposit of paint mist in said tail areas was observable. Only stably fan patterns of good quality were compared.

Under these conditions in this first example, the nozzle with the prior art restrictor entered the said threshold of running tails when the pressure at the gun was reduced to about 650 p.s.i. The nozzle employing our invention did not enter the threshold of running tails until the pressure at the gun was reduced to about 300 p.s.i. The nozzle with the prior art restrictor required a pressure of about 850 p.s.i. to reach the condition when the last, least noticeable deposit of paint mist in the said tail areas was observed. The nozzle comprising our invention required only 420 p.s.i. to reach the condition when the last, least noticeable deposit of paint mist in said tail areas was observed. When both the old restrictor and our new turbulence plate and screw were removed, running tails of more than threshold magnitude persisted above 850 p.s.i. Higher pressure was not employed to test their diminution or elimination.

Example II

In this example, all the conditions specified in example I were preserved except that a larger nozzle was employed having a capacity of 0.06 gallons with other characteristics tabulated above, and the *L*/*d* ratio was about 7:1. Also the depth of the groove of one of the inlet passages was 0.007 inches and the depth of the groove of the other was 0.0076 inches measured at the external ends of the grooves, the depth difference giving a slight bias. Their area combined to approximately equal the equivalent outlet orifice area. A restrictor of 0.016 orifice diameter was employed for comparison against the nozzle embodying our invention.

The nozzle employing the restrictor reached the threshold of running tails when the pressure at the gun was reduced down to 400 p.s.i., and the last misty traces of tails were substantially eliminated when the pressure of the gun was increased to about 600 p.s.i. The nozzle employing our invention did not reach the threshold of running tails until the pressure was reduced to about 300 p.s.i. and the last misty traces of tailing were substantially eliminated when the pressure was raised to 600 p.s.i.

Example III

In this example, everything was maintained the same as in example II, except that the inlet grooves in the turbulence plates, as measured at the end, were shallower so that one measured 0.0052 inches deep and the other 0.0055 inches deep. This also gave a slight bias, and the combined areas *x* plus *y*, FIG. 22, were only about two-thirds the equivalent area of the discharge orifice. This embodiment of our invention did not reach its threshold of running tails until the pressure at the gun had been reduced down to about 250 p.s.i.; albeit, the last misty traces of tails did not entirely disappear until the pressure of the gun was raised up to about 600 p.s.i. The readings with the restrictor were those of example II.

Example IV

This example continues with the same coating material and general test conditions as used in example I, except that the temperature of the coating material at the gun was dropped to about 100° F., resulting in a viscosity of 55 centipoise. Also the nozzle embodying the form of our invention shown in FIGS. **10** to **13** was employed which had a capacity of 0.14 gallons and *d* and *d'* as tabulated above, an *L*/*d* ratio of about 5.5:1, and lateral inlet passages of 0.0115 inches and 0.0112 inches in diameter which combined to provide a total inlet passage area approximately equal to the equivalent outlet orifice area. This was compared with the same size nozzle employing a 0.019 inch diameter orifice restrictor, no turbulence plate and an open upstream end of the approach passage.

The nozzle embodying our invention reached its threshold of running tails when the pressure at the gun was reduced to 200 p.s.i., and the last misty trace of tails was substantially eliminated when the pressure at the gun was increased to about 450 p.s.i. When the nozzle employing the restrictor was used, the threshold of running tails was reached when the pressure at the gun was reduced to 300 p.s.i., and the last misty traces of tails were not substantially eliminated until the pressure was increased to about 600 p.s.i. at the gun.

In the foregoing examples the relation of the gun pressure at the threshold of running tails to the higher or lower pressures at which the degree of tailing would not be objectionable for, nor deleterious to, fine finishing was not intended to be measured as such or exactly. The proximity of the threshold of running tails, under the conditions of the foregoing tests, to acceptable tail-free paint patterns for fine finishing was, as we observed and believed, such that the comparisons fairly measured the relative excellence and commercial utility of the tested devices.

The following examples are based on comparisons between the weight of paint deposited in a noticeable, detached tail with the weight of paint deposited in the main body of the spray pattern. These examples illumine and supplement the preceding examples, and are intended to give or approach mathematical bases for comparison.

This basis of comparison takes the premise that if not more than 1 percent of the total quantity of paint delivered to the whole target pattern is deposited in a clearly detached area, and covers an area of lateral width of no less than 10 percent of the width of the main portion of the pattern, that such a tail is harmless and offers no impediment to fine finishing. This is true because the maximum film thickness of such a tail will be less than one-tenth the thickness of the mean thickness of the film in the central body portion of the pattern. Such a tail, or symptom of a tail, of such thinness will be lost without detriment to fine finishing work in the next pass of the gun and in the overlap thereof.

To measure the thickness of paint deposited in such a tail for each of the nozzles to be compared, sample patterns for each nozzle were sprayed from a securely located gun on different vertically disposed corrugated sheets at different paint pressures beginning with low enough pressure to produce obviously objectionable tails and then increasing the pressure step by step and sheet by sheet until the tails began to appear on visual observation to be approaching the condition of a deposit of about 10 percent of the mean film thickness in the central portion of the pattern. Then when such a pre-10 percent condition was observed, the vertical line of the central thickest part of the tail was marked and measured from a fixed vertical reference line, and there was also marked and measured the distance from the reference line to the vertical line of the place of mean thickness of the paint film deposited in the central body portion of pattern taken half way between the end of the body portion near the tail and the middle of the body portion.

Thereafter two clean strips of aluminum foil, each having been weighed, were substituted for the corrugated sheet at the places where the tail and mean film thickness lines had been marked and measured. Then a vertical mask having equal vertical slots arranged to expose said vertical tail and mean film thickness lines, respectively, was laid over said strips and the gun actuated to repeat the preceding spray pattern on the mask and on the exposed areas of the film, care being taken to limit the quantity of paint sprayed to avoid loss of paint by "run-down" off the bottom edge of either strip or foil. The strips of foil and the slots in the mask were longer than maximum run-down that was recorded. The strips of painted foil were then baked and weighed, and the percentage of paint by weight deposited in the tail area compared with that deposited at the mean thickness of the body was noted with reference to the pressure at which the paint was sprayed.

This procedure was repeated at higher and/or different gun pressures until the condition that 10 percent of the mean film thickness of the body was deposited in the tail was bracketed and/or determined. This procedure was used for nozzles embodying our invention and for prior art nozzles-restrictor combinations for comparison of pressures required respectively to reduce the amount of paint deposited in the tail to 10 percent of said mean film thickness of the body. Such comparisons between nozzles of different sizes using white baking enamel at different temperatures and centipoise comprise our examples, Nos. V, VI and VII as follows:

Example V

Here the nozzles, restrictor and other physical aspects of the things tested and compared were the same as those specified in example III above, as the same incorporated and modified examples II and I seriatim. White baking enamel was used at 120° F. at 40 centipoise, and the procedure last above outlined was followed. When the prior art nozzle-restrictor combination was employed it required approximately 690 p.s.i. pressure at the gun to reduce the thickness of the paint deposit in the tail to 10 percent of the mean thickness of the deposit in the body. When the nozzle embodying our invention was employed only 340 p.s.i. pressure at the gun was required to get the same result.

Example VI

In this comparison the same procedure with the same paint at the same temperature and centipoise of example V was employed, and all other things were the same except that both our new and the old nozzles were of 0.09 gal./minute size and had an *L*/*d* ratio of 5.7:1; the restrictor employed with the prior art nozzle was 0.018 inches in diameter, but the turbulence plate employed in our nozzle corresponded in size to that of the 0.06 gal./minute nozzle as in example II so that the inlet area of the passages *x* and *y* was only about two-thirds the equivalent area of the orifice. See FIG. 22. Under these conditions the prior art combination required approximately 340 p.s.i. pressure at the gun to get the thickness of the tail down to 10 percent of the mean film thickness of the body portion of the pattern, whilst our nozzle required but 260 p.s.i. pressure to get the same result.

Example VII

In this comparison everything was the same as in example VI except the nozzles were larger, of 0.14 gal./minute size, the temperature of the same paint was lowered to 100° F. and the centipoise raised to 55, the *L*/*d* ratio of our nozzle was 5.5:1, the sum of the *x* and *y* inlet passage areas in our turbulence plate was about two-thirds the effective area of the nozzle orifice, and the restrictor of the prior art combination had a 0.019 inch diameter. Under these conditions it required approximately 400 p.s.i. pressure with the old combination to get the tail thickness down to the desired 10 percent of the mean body thickness as aforesaid, while with our new nozzle approximately 350 p.s.i. sufficed to get the same result.

While we have illustrated and described certain preferred and modified forms and embodiments of our invention and the best modes presently contemplated by us for carrying out our invention, changes, equivalents, and improvements will occur to those skilled in the art who come to understand and enjoy our invention without departing from the essential principles and precepts thereof. Therefore we do not want our patent to be limited to the forms, embodiments and modes herein specifically illustrated and described, nor in any manner inconsistent with the progress by which our invention has promoted the art.

We claim:

1. In a liquid spray nozzle having flow capacity of not more than about 20 gallons of water per hour at 500 p.s.i., comprising a body having a central void, comprising at least in part an approach passage, with a longitudinal axis and a fan spray outlet orifice at one end of said passage and with a side inlet at the other end of said passage and with an imperforate sidewall from said one end to said inlet, the area of said inlet being harmoniously related to the effective area of said outlet in respect to turbulent flow therebetween, the improvement comprising means for preventing the longitudinal inflow of liquid to the inlet end of said passage and defining a turbulence chamber in said void adjacent said inlet, and liquid inlet conducting means for introducing liquid into said chamber transversely of said axis with velocity and direction tending to induce turbulence in said chamber and avoid substantial bodily rotation of the fluid stream in said passage about said axis adjacent said orifice; both said means and said passage coacting to create a turbulent stream in said passage with substantially uniform mean velocity across the whole stream at said one end of said passage.

2. The nozzle of claim 1 wherein the cross-sectional area of said inlet conducting means is substantially equal to the equivalent circular area of said discharge orifice, plus about 20 percent, minus about 30 percent.

3. The improvement of claim 2 wherein said central passage is between 4 to 10 times as long as its diameter adjacent said orifice and has a tendency to convert the turbulence in said chamber to a stream of substantially uniform axial velocity throughout its whole cross section adjacent said orifice.

4. In a spray nozzle comprising a body having a central passage with a longitudinal axis and a fan spray orifice at one end of said passage, the improvement comprising means for preventing the longitudinal inflow of fluid to the opposite end of said passage and defining a turbulence chamber in said passage at said opposite end, and fluid inlet conducting means for introducing fluid into said chamber transversely of said axis with motion and direction tending to induce turbulence in said chamber and prevent substantial bodily rotation of the fluid stream in said passage about said axis adjacent said orifice, said central passage being open at said opposite end of said body, and said first named means comprising a turbulence plate movable toward and away from the said opposite end of said body and comprising in coaction therewith said inlet conducting means.

5. The improvement of claim 4 wherein the said opposite end of said body has a flat face normal to said axis and said turbulence plate is bodily movable in the direction of said axis and has a surface mating with said face.

6. The improvement of claim 4 wherein said central passage is between 4 to 10 times as long as its diameter adjacent said orifice and has a tendency to convert the turbulence in said chamber to a turbulent stream of substantially uniform axial velocity throughout its whole cross section adjacent said orifice.

7. In a spray nozzle comprising a body having a central passage with a longitudinal axis and a fan spray orifice at one end of said passage, the improvement comprising means for preventing the longitudinal inflow of fluid to the opposite end of said passage and defining a turbulence chamber in said passage at said opposite end, and fluid inlet conducting means for introducing fluid into said chamber transversely of said axis with motion and direction tending to induce turbulence in said chamber and prevent substantial bodily rotation of the fluid stream in said passage about said axis adjacent said orifice, said central passage being open at said opposite end of said body, and said first named means comprising a turbulence plate at the said opposite end of said body and comprising in coaction therewith said inlet conducting means.

8. The improvement of claim 4 in which said turbulence plate has a recess substantially coextensive with said passage and comprising part of said turbulence chamber.

9. The improvement of claim 8 in which said recess comprises a wall opposite said passage and normal to said axis and fluid is introduced to said chamber between said recess and the said opposite end of said passage.

10. The improvement of claim 9 wherein said body at the opposite end of said passage and said turbulence plate have juxtaposed surfaces, one of which is grooved to comprise said inlet conducting means.

11. The improvement of claim 1 wherein said inlet conducting means comprises only one lateral passage having its axis substantially intersecting the said axis of said central passage.

12. The improvement of claim 1 wherein said inlet conducting means comprises oppositely disposed and axially aligned lateral passages.

13. The improvement of claim 1 wherein said inlet conducting means comprises a plurality of paths directing fluid into collision in said chamber.

14. The improvement of claim 4 wherein said body at the opposite end of said passage and said turbulence plate have juxtaposed surfaces, one of which is grooved to comprise said inlet conducting means.

15. The improvement of claim 7 wherein said body at the opposite end of said passage and said turbulence plate have juxtaposed surfaces, one of which is grooved to comprise said inlet conducting means.

16. The improvement of claim 7 wherein said passage is from about 4 to 10 times as long as its diameter at said one end of said passage and tapers to a greater diameter at said opposite end whereby to accelerate said stream toward said orifice.

17. The improvement of claim 16 wherein the cross-sectional area of said inlet conducting means is commensurate with the effective area of said orifice and the velocity of fluid being introduced to said turbulence chamber is from about 30 percent more to about 20 percent less than the velocity of fluid being discharged through said orifice.

18. An hydraulic airless spray nozzle suitable for fine finishing by delivering a finely atomized spray of coating material in a selected pattern upon work to be finished, comprising a nozzle tip having a central passage, including an approach passage, having a longitudinal axis and having a discharge orifice smaller than the approach passage adjacent thereto at one end of both said passages at one end of said nozzle tip, said approach passage having a lateral inlet longitudinal spaced from said orifice sufficiently to enhance the quality of the stream adjacent said orifice and having an imperforate sidewall between said orifice and said inlet, means adjacent the other end of said central passage preventing the inflow of liquid longitudinally to the other end of said approach passage, said central passage comprising a turbulence chamber adjacent said inlet, inlet passage means for conducting liquid into said chamber adjacent a plane substantially normal to said axis, and means for changing the direction of flow of liquid abruptly and turbulently in said chamber and causing said liquid to flow to said orifice in a turbulent stream without substantial bodily rotation and with its constituents moving parallel to said axis with substantial uniform velocity across substantially the whole cross section of said one end of said passages.

19. The nozzle of claim 18 wherein said inlet passage means comprises only one inlet substantially corresponding in area to the equivalent area of said orifice, plus or minus about one-third and has its longitudinal axis substantially perpendicular to and intersection the longitudinal axis of said approach passage.

20. The nozzle of claim 18 wherein said inlet passage means comprises a plurality of passages aimed to project fluid streams into collision in said turbulence chamber.

21. The nozzle of claim 20 comprising two passages axially aligned and oppositely disposed.

22. The nozzle of claim 21 in which said two passages are unequal.

23. A spray nozzle comprising a central passage having a longitudinal axis, a discharge orifice at one end of said passage at one end of said nozzle, means adjacent the other end of said nozzle preventing the inflow of fluid longitudinally to the other end of said passage, said passage comprising a turbulence chamber adjacent said other end of said nozzle, inlet passage means for conducting fluid into said chamber in a plane substantially normal to said axis, and means for changing the direction of flow of fluid abruptly and turbulently in said chamber and causing said fluid to flow to said orifice in a stream without substantial bodily rotation and with its substantial constituents moving parallel to said axis with substantial uniform velocity across substantially the whole cross section of said one end of said central passage, said first named means comprising a turbulence plate movable in the direction of said axis toward and away from the said other end of said nozzle.

24. The nozzle of claim 23 wherein said turbulence plate and the said other end of said nozzle have mutually juxtaposed plane faces, and said inlet passage means comprises a groove in one of said faces.

25. The nozzle of claim 24 wherein said turbulence plate includes a recessed cavity in substantial alignment with said central passage and comprises said turbulence chamber therewith.

26. A spray nozzle comprising a central passage having a longitudinal axis, a discharge orifice at one end of said passage at one end of said nozzle, means adjacent the other end of said nozzle preventing the inflow of fluid longitudinally to the other end of said passage, said passage comprising a turbulence chamber adjacent said other end of said nozzle, inlet passage means for conducting fluid into said chamber in a plane substantially normal to said axis, means for changing the direction of flow of fluid abruptly and turbulently in said chamber and causing said fluid to flow to said orifice in a stream without substantial bodily rotation and with its substantial constituents moving parallel to said axis with substantial uniform velocity across substantially the whole cross section of said one end of said central passage, the said other end of said nozzle having a surface normal to said axis, a separate turbulence plate comprising said first named means, and means for supporting said turbulence plate closely adjacent said surface and spaced from the upstream end of said passage and comprising said inlet passage means.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,556,411 Dated 18th February 1971

Inventor(s) Nord, Rood & Bosworth

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 26, change, "(b4)" to --(4)--

Column 1, line 57, before "closure", change "and" to --end--

Column 3, line 26, change "turbulence" to read --turbulent--

Claim 3, line 1, i.e. Column 14, line 30, erase "central"

Claim 11, line 3, i.e. Column 15, line 14, erase "central"

Claim 19, line 5, i.e. column 16, line 7, change "intersecti
to read --intersecting--

Signed and sealed this 1st day of June 1971.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents