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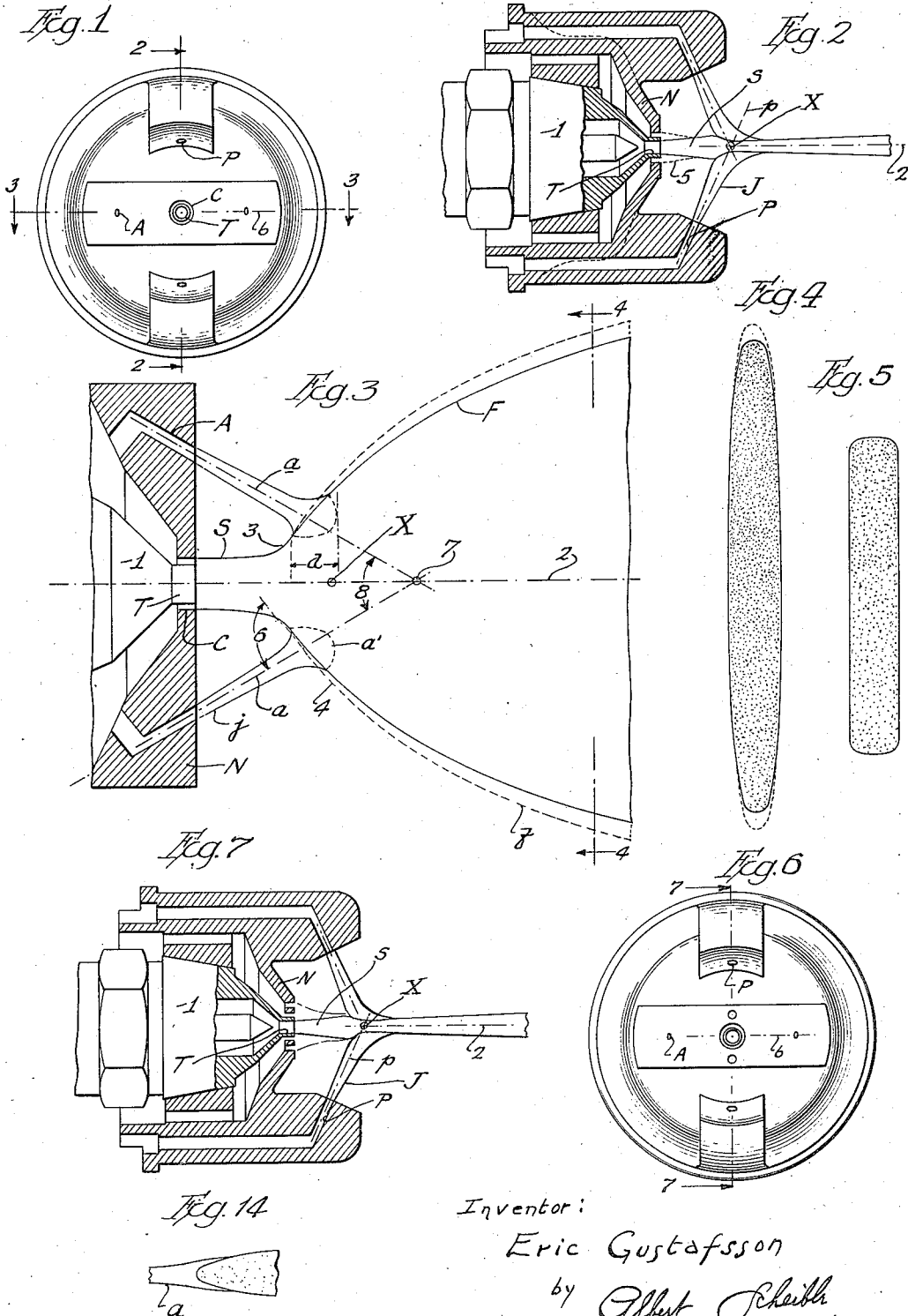
E. GUSTAFSSON

2,049,700

AIR NOZZLE FOR FLAT SPRAYING APPLIANCES

Filed July 15, 1935

2 Sheets-Sheet 1



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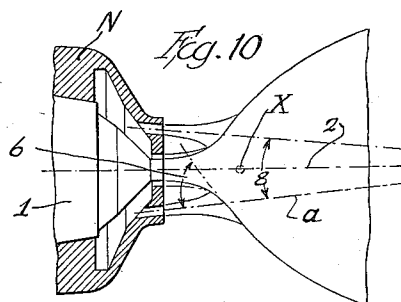
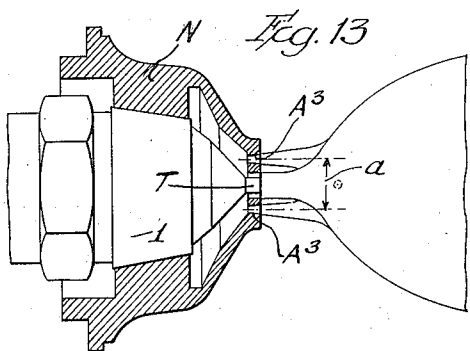
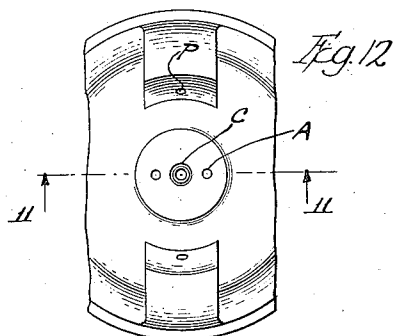
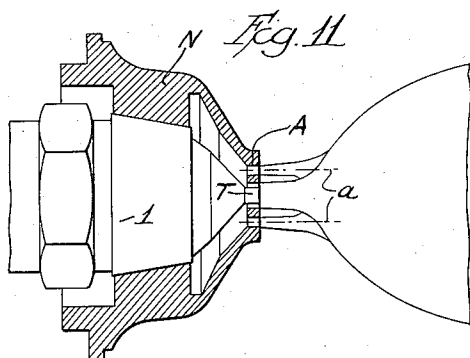
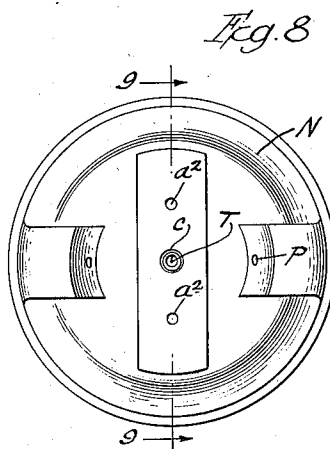
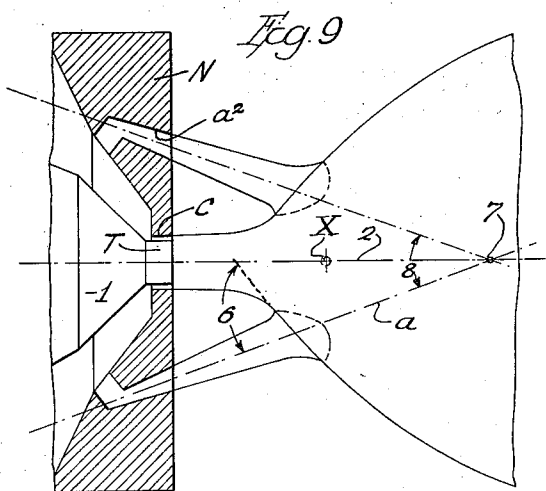
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AIR NOZZLE FOR FLAT SPRAYING APPLIANCES

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,049,700

AIR NOZZLE FOR FLAT-SPRAYING
APPLIANCESEric Gustafsson, Chicago, Ill., assignor to Binks
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Application July 15, 1935, Serial No. 31,350

12 Claims. (Cl. 299—140.1)

My invention relates to spray appliances constructed for having a forwardly projected (and usually partially aerated) stream of material flattened by the impact of two opposed jets of air to a substantially elliptical or elongated rectangular section and thereafter spread out into a fan-shaped spray. Modern spray guns of this class usually provide a separate air control for the side air jets, whereby the cross-section of the resulting spray (which would be circular without such side jets, and elliptical with a relatively light impact of these side jets) can be adjusted to afford the commercially most desirable pattern—namely one having substantially parallel longitudinal sides of much greater length than their spacing, and having only slightly rounded or substantially straight ends.

In one of its major objects, my invention aims to provide simple means for reducing the "off-spray" beyond the general pattern of the spray, and particularly that beyond the ends of the pattern, so as to permit a clean-contoured pattern to be produced even at a high spraying rate, without requiring an undesirably large total consumption of compressed air. Moreover, my invention aims to provide means for this purpose which can readily be varied according to the nature of the projected material, and also to suit other operating conditions, and which means can readily consist of simple auxiliary bores provided in the usual air nozzle of a modern spray gun.

When a non-homogeneous material, as for example vitreous enamel (consisting of finely ground vitreous material suspended in a carried liquid) is flat-sprayed from a conventional modern spray gun and the material stream is sufficiently flattened to produce such a parallel-sided pattern, the resulting spray is apt to project an undesirable amount of so-called off-spray beyond the general contour of the pattern, and particularly beyond the ends of the elongated pattern, thereby marring the desired uniformity of the coating.

The just recited difficulty was overcome, as disclosed in United States Patent #1,897,173 (issued February 3, 1933 to Robert Long and myself) by projecting additional air against the two sides of the material stream toward which the spray is to be spread, so as to preflatten this stream, before it receives the impact of the side air jets, to an elliptical section having its longer axis in the same plane with the axes of the side air jets. This proved quite satisfactory in practice, both for reducing the so-called "off-spray" with vitreous

enamels and also for producing a cleaner-edged pattern with many other coating materials, when these materials were sprayed at a rate which formerly was considered as adequately fast.

However, in more recent years many large users of spray guns—such as the automobile manufacturers—have desired a considerable reduction in the spraying time, namely the time required for spray-coating a given surface area, and when used at such speedier spraying rates, spray guns equipped with the air nozzle of the aforesaid patent have required an undesirably large total consumption of compressed air.

This I judge to be due to the following reasons: To reduce the spraying time, the material must be projected at higher speed, as also the air which issues from the air nozzle around and in merging relation to the projected material stream. In addition, the augmented air for pre-flattening the stream according to the aforesaid patent must issue at a correspondingly greater rate, particularly since considerable energy is required for forcibly deforming such a material stream to a changed cross-section. Moreover, more air is required from the side air jets for their flattening action than would have been needed if the stream had not been preflattened in a direction transverse to that in which the spray is to be flattened. In addition, the preflattening action somewhat reduces the speed of the material stream, thereby requiring additional air to be used for propelling it at the desired rate.

In considering the problem of avoiding a fraying of the side edges of the fan-like shape of the flattened stream part which later on spreads farther into a spray, and in which such fraying produces off-spray at the ends of the spray pattern, with a view to devising an air-saving substitute for the Long and Gustafsson air nozzle, I have made these observations:

(a) This fan-like stream part presents rearwardly and laterally convexed shoulders at opposite sides of the axis of the stream, into which shoulders the initially terete (or slightly flaring) cylindrical streams curvedly merge. In each shoulder portion adjacent to the curving merging, the stream usually spreads (laterally of the fan shape) at least as fast as it moves forwardly, which implies that the lateral velocity of the stream particles in such a portion of the stream must be much greater than in portions of the fan-shaped stream part farther from the issue point of the material stream. Consequently, means applied to these shoulders should be highly effective in deterring the fan-edge fraying which

later on produce off-spray at the ends of the elongated spray pattern.

(b) These shoulder portions are much thinner than the diameter of the initially projected stream, so that air jets projected against such portions should be far more efficient in preventing a fan-edge fraying than when projected against the unflattened stream portion after the manner of the aforesaid patent.

(c) When forwardly converging air jets are projected (for the here discussed purpose) against such shoulder portions of the fan-shaped stream part with the jet axes in the plane along which the stream was flattened, each such jet (when of suitable size) will straddle the edge of such a shoulder portion so as to smooth both the fan-edge contour of the shoulder and considerable portions adjacent to that edge, thereby also producing a generally sharper and cleaner edge in the spray pattern.

(d) That auxiliary air jets can effectively be directed against the said shoulders for my above recited purposes at considerably varying angles, thereby varying the extent to which these jets aid in propelling the material stream and also permitting such auxiliary air jets to be used efficiently with materials of widely varying characteristics.

Illustrative of the manner in which I have utilized my above recited observations by adding suitably positioned auxiliary air ports to a conventional type of an air nozzle for a spray gun.

Fig. 1 is a front elevation of an air nozzle having two auxiliary air ports in the novel disposition of my present invention, with the axes of these ports converging at an angle of 60 degrees.

Fig. 2 is a diametric cross-section taken in the plane along which the spray is to be flattened (namely, along the line 2-2 of Fig. 1) through the same air nozzle and through a material nozzle associated with it, including contours of the material stream, the central port air which merges with this stream, and the side air jets.

Fig. 3 is a diametric cross-section through the same two nozzles, taken in a plane at right angles to that of Fig. 2, showing the air jets emitted from the auxiliary air ports and their effect on the fan-shaped spreading of the material by the side air jets.

Fig. 4 is a cross-section of the resulting spray, taken along the line 4-4 of Fig. 3, with dotted portions showing the increased length which this section would have had if my auxiliary air ports had been omitted.

Fig. 5 is a reduced elevation of the more rectangular, or parallel-sided, spray pattern which would be produced if more side air were projected than for the elliptical pattern of Fig. 4.

Fig. 6 is a front elevation of an air nozzle allied to Fig. 1, but also including supplemental ports—arranged after the manner of my United States Patent #1,990,824 for producing ribs on the material stream, against which ribs the side air jets impact.

Fig. 7 is a section, taken along the line 7-7 of Fig. 6 through the air nozzle of that figure and the material nozzle associated with it, showing the action of this nozzle assembly.

Fig. 8 is a front elevation of an air nozzle in which my auxiliary air ports are positioned for projecting air jets with their axes converging at an angle of 40 degrees.

Fig. 9 is an enlarged section taken along the line 9-9 of Fig. 8, with contour lines indicating the resulting action.

Fig. 10 is a section allied to Figs. 3 and 9, but drawn on a smaller scale, showing the auxiliary ports as disposed so that the axes of the auxiliary air jets converge at an angle of only 20 degrees.

Fig. 11 is a section allied to Fig. 10, showing axially coparallel auxiliary ports of cylindrical bores.

Fig. 12 is a fragmentary front elevation of the air nozzle of Fig. 11.

Fig. 13 is a section, for comparison with Fig. 11, showing the difference in the effect of the auxiliary ports when these have forwardly flaring bores.

Fig. 14 is an enlarged section, taken along the auxiliary jet axis a of Fig. 3 and at right angles to the plane of the drawing, showing how the air jet projected along that axis straddles the shoulder portion of the material stream against which that jet is directed.

In the drawings, Fig. 2 shows a conventional material nozzle 1 having a cylindrical-tubular tip T for projecting an initially circular sectioned material stream. Fitted upon this material nozzle in a long customary manner is an air nozzle N having a central air port C coaxial with and freely housing the material nozzle tip, so as to permit air 5 to issue from that port around and in merging relation to the material stream S as shown diagrammatically in Fig. 2. In addition, the air nozzle has the usual side air ports P for projecting side air jets J against opposite sides of the material stream to flatten the latter.

If the air nozzle had only the just recited features, the projecting of the side air jets with their axes intersecting at a point X on the stream axis 2 would flatten the forwardly projected material stream approximately as shown in Fig. 2, and with a given pressure of the side air would give the unitary flattened part of the stream (before this breaks up) a fan-shaped contour f such as is shown in dotted lines in Fig. 3, with the base end of the fan shape merging by curves 3 into laterally opposite shoulder portions 4, each of which is convexed both rearwardly and laterally away from the axis of the material stream.

To form such contour shoulders, part of the material, while moving forwardly for a distance d (Fig. 3) just beyond the curvedly flared stream portion 3 must move quite rapidly away from the stream axis. Consequently, the momentum imparted by this velocity to any relatively heavy particles of the material will tend to project such particles farther (laterally away from the stream axis) than the lighter material constituents.

In practice, both the viscosity of the lighter portions of the material (as for example, the liquid in which vitreous granules are suspended) and the surface tension of the liquid tend to deter the heavier particles from being flicked out of the lighter material portions immediately. But the greater weight of the heavier particles apparently begin to separate minute streamer-like liquid-coated portions of the material stream before the material has moved forwardly far beyond the shoulder portions reaching through the said distance d , and some of the flicking tendency apparently begins even in the stream portion (behind the said shoulders) which has the curved edges 3.

To prevent the deleterious effect which the just recited actions have on the spray pattern, I provide two auxiliary air ports each disposed for projecting an auxiliary air jet against one of the said shoulders so as to act on the fan-edge por-

tions of the material stream in which the above described lateral movement of the stream particles is relatively rapid. These auxiliary ports A have their axes a symmetrically disposed with respect to the axis 2 of the central air port, and in the plane 6 (diametric of the said central port) along with the spray is flattened, namely a plane at right angles to the common plane of the axes p of the side port P.

Moreover, each auxiliary port is positioned so that the air jet j projected by it will be freely spaced from the unflattened part of the material stream, and each such port preferably has its bore diameter a minor fraction of that of the central air port C. In addition, each auxiliary port A preferably is disposed for projecting its air either entirely against an edge portion of the fan contour of the flattened stream part, which portion is adjacent to the juncture of one of the said convex shoulders with the curved merging of the shoulder into the not yet flattened part of the stream.

Working within the above recited limits, which prolonged experiments have shown to be desirable—at least with the now customary coating materials, air pressure and spraying speeds—I have found that my here presented nozzles can be considerably varied in the disposition of the auxiliary ports so as to meet different operating conditions.

Thus in Fig. 3, the port axes a converge at an angle of 60 degrees; so that each such port axis is almost at right angles to the portion of the dotted curve f toward which the jet from that port is directed. Thus arranged, the portions of the air of each such jet which are adjacent to the plane 2 in which the spray is to be flattened (and along which the material stream is flattened for that purpose) effectively resist the spreading of the stream to some extent, while jet portions farther from that plane are initially deflected by the material so that each such air jet presents a portion a^1 which straddles the impacted shoulder portion of the flattened material stream, as shown in Fig. 14, before merging with the latter. This straddling probably accounts for a considerable part of the resulting smoothing of the contour of the spray pattern.

When the axes a of the auxiliary ports converge at an angle of 40 degrees, as in Fig. 9, the auxiliary jets exert a larger share of their energy in the direction in which the material stream was projected, so as to contribute more toward the velocity of the stream; and the extent of this stream-propelling effect is increased still more when the said port axes a converge at an angle of only 20 degrees, as in Fig. 10. Moreover, instead of making the auxiliary ports with cylindrical bores, as in Figs. 3 and 10, these may have tapering bores increasing forwardly in diameter, as shown for the ports a^2 of Fig. 9, so that each projected auxiliary air jet will have more of a stream-straddling effect.

Comparing Fig. 10 with Figs. 1 and 9, it will be noted that the intersection of the axes a of the auxiliary jets intersecting at a point I which advances forwardly as the angle of convergence between these jet axes is decreased; so that this intersection point I in Fig. 3 is fully 50 percent farther forward from the starting point of the projected material stream than the intersection X of the axes of the side air jets.

This increase in the forward spacing of the point I grows as the angle of convergence θ of the jet axes decreases, as shown successively in Figs. 9 and 10; and in practice this angle can be

decreased to zero, as in Fig. 11, by making the auxiliary jet axes parallel, provided that the auxiliary jets are freely spaced from the not yet flattened part of the material stream and are sufficiently near that stream part so that the axis of each such jet will intersect the impacted shoulder portion of the flattened stream at an inwardly open acute angle ϕ of at least about 45 degrees. With the material stream flattened to the maximum extent now customary for spray guns, this angle ϕ can be fully 80 degrees, as in Fig. 3, where the jet axes a converge at an angle of 60 degrees; but I have found that any increase of the said angle ϕ beyond about 80 degrees would be detrimental for my purpose, because the auxiliary jets then will unduly shorten the spray pattern.

Moreover, within the here illustrated desirable range of the angle of convergence θ between the axes of my auxiliary jets—namely between 60 degrees and zero—a major portion of the energy of each such jet is expended in accelerating the velocity of the projected material, so as partially to offset the velocity-retarding due to the impact of the stream-flattening side air jets.

Since this acceleration increases as the said angle of convergence is decreased, while the off-spray-preventing and pattern-smoothing effect increases with an enlargement of the said angle, I can readily adapt my new air nozzle to widely varying materials by merely varying the angle at which each auxiliary port is bored, with respect to the axis of the central air port C.

So also, I can vary both the velocity-accelerating or spray-propelling effect and the extent to which my auxiliary air jets contribute to the atomization of the spray by varying the bore diameters of the auxiliary ports, or by making each such bore flare forwardly somewhat. Thus, Fig. 13 shows each auxiliary port A^3 as having a forwardly flaring bore, which I have found particularly desirable when the spacing of the material nozzle tip T from the bore of the central air port C is unusually small so that additional air is needed for adequately atomizing the material.

However, while I have heretofore described my invention in connection with an air nozzle of otherwise conventional type, it should be obvious that my novel spray-improving method does not hinge on the here particularly illustrated means for projecting the needed auxiliary air jets.

So also, while I have particularly mentioned the advantages which my invention affords by preventing off-spray with certain materials—such as vitreous enamels, glazings and so-called synthetic enamels—I have also found my here described air nozzle desirable with many homogeneous materials, such as lacquers, because it permits a higher spraying speed to be obtained without reducing the degree of atomization and without introducing any streaking of the spray or tendency to split the spray.

I claim as my invention:

1. In the production of a flattened spray of material by the projecting of forwardly converging jets of air against opposite sides of a projected stream of material so as to deform the stream of a fan-shaped contour presenting rearwardly facing and laterally opposite contour shoulders near the unflattened part of the stream, the method of preventing a fraying of the side edges of the said fan-shaped contour, which method consists in forwardly projecting two jets of air freely spaced from the not yet flattened

part of the material stream and directed respectively against the said shoulders, with the axes of the two jets disposed in the plane along which the stream is flattened and symmetrical with respect to the axis of the projected stream, and with the said jet axes converging forwardly at an angle of not more than 60 degrees.

2. The method recited in claim 1, in which each of the said jets is formed of such a diameter as to cause the jet to straddle the shoulder portion against which that jet is directed, before all of the air of the jet merges with the material of the stream.

3. The method of smoothing contour portions of the pattern produced by a forwardly projected stream of material after the said stream has been flattened along a plane diametric of the stream by the impact of opposed jets of air having their axes intersecting on the axis of the said stream, which method comprises the simultaneous projection, against fan-shoulders of the flattened stream portion, of two opposed auxiliary jets of air having their axes disposed in the said plane and intersecting on the axis of the stream at a point at least 50 percent further forward from the starting point of the stream than the aforesaid intersection; and with the axis of each auxiliary jet engaging a fan-shaped edge portion of the flattened stream part at a major acute angle opening toward the stream portion back of that stream part.

4. A spray appliance of the class in which a forwardly projected stream of aerated material is flattened, by the impact of two forwardly converging side jets of air against opposite sides of the stream, to a fan shape presenting two rearwardly convexed shoulders at opposite sides of the axis of the stream, and in which the axes of the said side jets are a plane diametric of the axis of the projected stream, characterized by including means for projecting two auxiliary and forwardly converging jets of air with their axes disposed in a second plane diametric of the stream axis and at right angles to the aforesaid plane; the said auxiliary jets having their axes intersecting at a point on the stream axis farther forward from the starting point of the stream than the intersection of the said side jets, the auxiliary jets being directed respectively against portions of the said two shoulders adjacent to the junctures of the said shoulders with the not yet flattened part of the stream.

5. A spray appliance as per claim 4, in which the said means are constructed so that the auxiliary jets are initially of smaller diameter than the side jets are initially, and in which the auxiliary air jets have their axes intersecting on the stream axis at an angle of not exceeding approximately sixty degrees.

6. A spray appliance of the class in which a forwardly projected stream of aerated material is flattened along a plane housing the axis of the stream, by the impact of two forwardly converging side jets against opposite sides of the stream, to a fan shape presenting two rearwardly convexed shoulders at opposite sides of the axis of the said stream, and in which the axes of the said side jets are a plane diametric of the axis of the projected stream, characterized by including means for forwardly projecting two auxiliary jets of air symmetrically with respect to the stream axis, with the axes of the auxiliary air jets disposed in the said plane and directed respectively against portions of the said two shoulders adjacent to the juncture of the said shoulders

with the not yet flattened part of the stream; and with the axis of each auxiliary jet at an angle of between zero and 30 degrees to the axis of the said stream, and at an inwardly open major acute angle to the edge of the shoulder against which that jet is directed.

7. A spray appliance as per claim 6, in which the said means are constructed so that each auxiliary air jet initially flares forwardly at a cone taper angle of between zero and approximately 10 to 20 degrees.

8. In a spray appliance of the class in which a stream of material is projected forwardly through an axial port in an air nozzle, and in which the air nozzle also has side air ports for projecting side jets of air forwardly respectively against opposite sides of the said stream along forwardly converging axes having their intersection on the axis of the said central port, whereby the side air jets flatten the material stream to cause the latter to present rearwardly and laterally bowed shoulders at opposite sides of the axis of the said stream; an air nozzle characterized by having in addition to the said central air port and side air port two auxiliary ports of smaller diameter than the side air ports; the said auxiliary ports having their axes in the plane along which the stream is flattened and being disposed for projecting air along axes which intersect on the axis of the material stream at a point at least one half farther from the outlet of the said central air port than the aforesaid intersection; the angle at which the axes of the auxiliary ports converge being materially less than the angle of convergence of the axes of the side air ports, and the said auxiliary port axes being disposed so that the air projected by these ports is directed respectively against portions of the said shoulders which are near to but spaced from the rear end of the stream part which is flattened by the side air jets.

9. A spray head comprising means for forwardly projecting an aerated stream of material, means for projecting two forwardly converging side jets of air against opposite sides of the projected material stream to produce a flattened stream portion presenting laterally oppositely directed and rearwardly convexed shoulders near the not yet flattened portion of the said stream; and means for projecting two forwardly converging auxiliary air jets respectively against and in initially straddling relation to the said shoulders, with the axes of the auxiliary air jets disposed in the plane along which the said stream portion was flattened, the last named jet axes intersecting at a point on the axis of the stream which is at least one-half farther forward from the starting point of the projected material stream than the intersection of the said side air jets.

10. For use in a flat spraying appliance, an air nozzle having at its front the usual central air port, and the usual forwardly converging side air ports presenting their axes in a common plane diametric of the central air port and having their said axes intersecting on the axis of the said central port; the air nozzle being characterized by also having two auxiliary air ports, symmetrically disposed with respect to the central air port and with their axes in a second plane diametric of the central air port and at right angles to the said plane; the said auxiliary ports having their axes intersecting on the said central port axes at a point at least one-half farther forward from the outlet of the central air port than the intersection of the axes of the side air ports.

11. A spray appliance of the class in which a forwardly projected stream of aerated material is flattened along a plane housing the axis of the stream, by the impact of two forwardly converging side jets against opposite sides of the stream, to a fan shape presenting two rearwardly convexed shoulders at opposite sides of the axis of the said stream, and in which the axes of the said side jets are in a plane diametric of the axis of the projected stream, characterized by including means for forwardly projecting two auxiliary jets of air symmetrically with respect to the stream jet axis, with the axes of the auxiliary air disposed in the first recited plane and directed respectively against portions of the said two shoulders adjacent to the juncture of the said shoulders with the not yet flattened part of the stream, with the axis of each auxiliary jet at an angle of between zero and 30 degrees to the axis of the said stream, and with each auxiliary jet axis at a major acute angle, opening toward the axis of the material stream, to the edge of the shoulder portion against which that jet is directed.

12. In a spray appliance of the class in which a forwardly projected stream of aerated material is flattened, by the impact of two forwardly converging side jets against opposite sides of the

stream, to a fan shape presenting two rearwardly convexed shoulders at opposite sides of the axis of the stream, and in which the axes of the said side jets are a plane diametric of the axis of the projected stream, an air nozzle including means for projecting two auxiliary jets of air forwardly to cause these air jets to impact directly against and in straddling relation to portions of the said shoulders near the juncture of these shoulders with the not yet flattened part of the said stream, with the auxiliary jets symmetrically disposed with respect to and projected at opposite sides of the material stream; and with the axes of the auxiliary jets disposed in a second plane along the axis of the stream and at right angles to the aforesaid plane, and converging at such an angle that a minor portion of the energy of each auxiliary jet acts for resisting the flattening of the stream by the said side jets while a major portion of the said energy aids in forwardly propelling the flattened stream; the starting points of the said air jets being sufficiently spaced from the starting point of the material stream, so that each such jet does not merge with an unflattened portion of the said stream.

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