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[54] **ECCENTRIC SPIRAL SWIRL CHAMBER NOZZLE**

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[52] **U.S. Cl.** **239/468**
[51] **Int. Cl.** **B05b 1/34**
[58] **Field of Search** 239/468

[56] **References Cited**

UNITED STATES PATENTS

3,532,271	10/1970	Polnauer	239/468
1,716,175	6/1929	Klein	239/468
1,938,000	12/1933	Wahlin	239/468
2,904,263	9/1959	Tate et al.	239/468 X

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[57] **ABSTRACT**

In a spiral swirl chamber nozzle, the spray orifice and axial origin of the spiral of the spiral swirl chamber are eccentrically offset from each other in a sector of the swirl chamber between approximately 90° to 150° from the maximum radius of the spiral adjacent the fluid inlet and in the direction of fluid rotation in the chamber and by a distance of approximately 0.005 to 0.015 inch.

5 Claims, 3 Drawing Figures

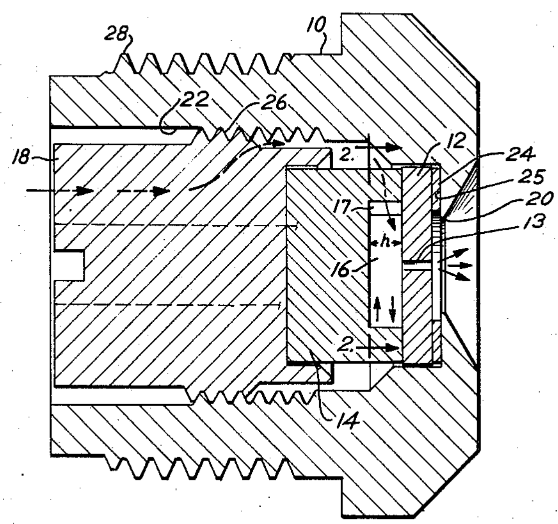


Fig. 1

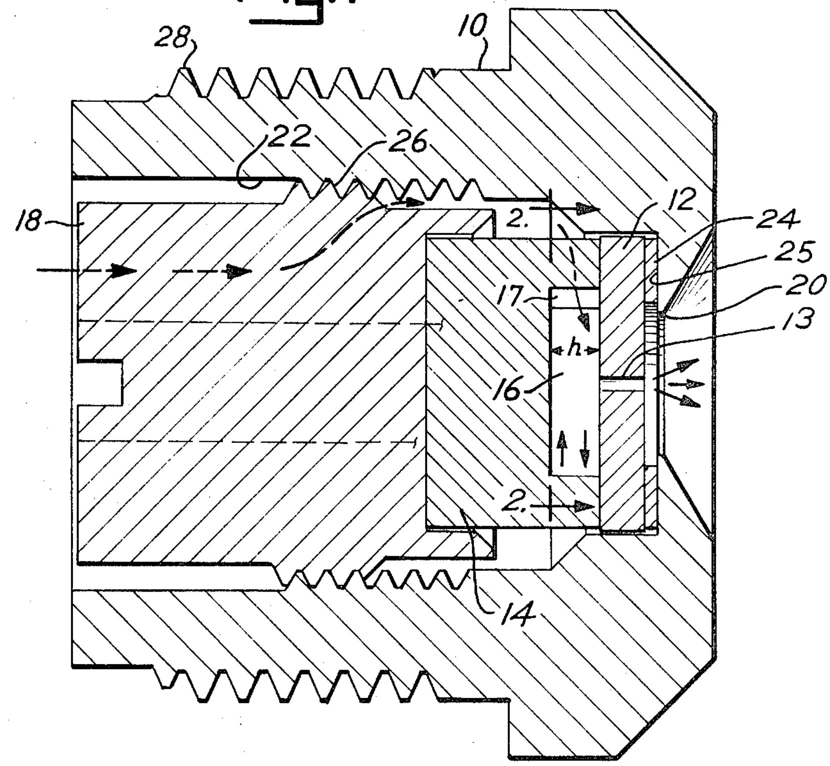


Fig. 2

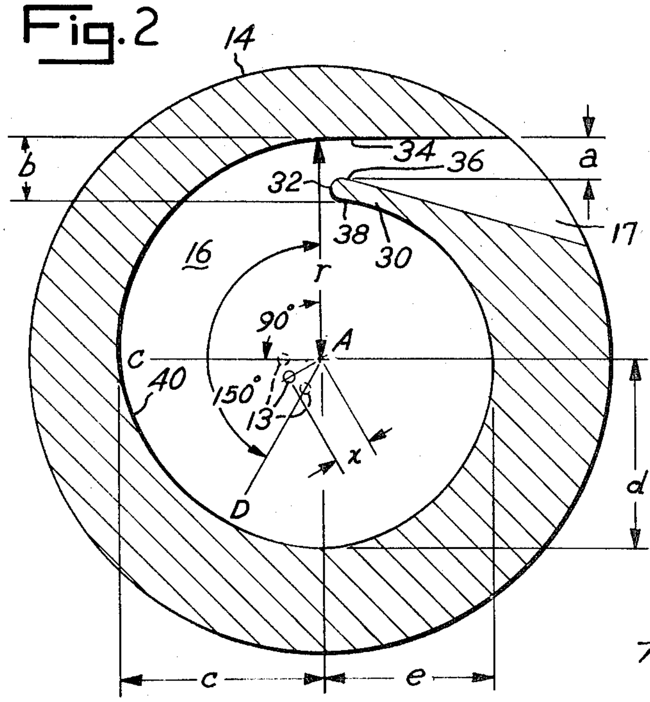
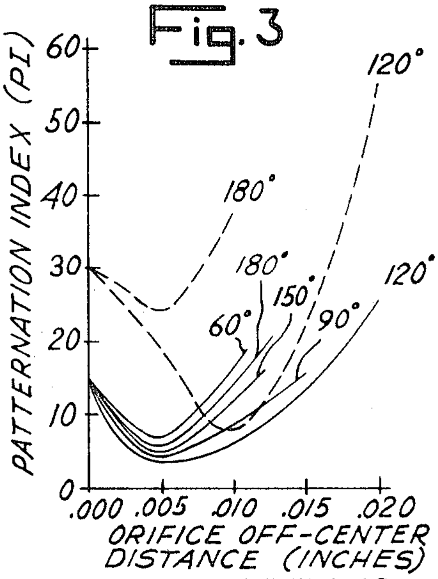


Fig. 3



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ECCENTRIC SPIRAL SWIRL CHAMBER NOZZLE

BACKGROUND AND SUMMARY OF THE INVENTION

This invention relates to fluid nozzles and, more particularly, to improved fluid nozzles of the type employing a spiral swirl chamber.

Fluid nozzles or atomizers having centrifugal swirl chambers upstream of the spray orifice have been employed in the past in various uses, including spray drying, aeration, cooling, and fuel injection. One form of swirl chamber which has been employed is a single inlet circular swirl chamber. Such circular chamber devices suffer the principal disadvantage of poor spray distribution or patternation, since the axis of rotation of the fluid in the circular swirl chamber will be displaced somewhat during use from the geometric center of the circular chamber.

In order to overcome the defective spray patternation of these circular swirl chamber nozzles which occurs during use, several approaches have been followed in the past. One of these approaches is to eccentrically offset the spray orifice of the nozzle and the geometric center of the circular swirl chamber relative to each other such that the orifice more closely coincides with the axis of rotation of the fluid in the chamber. Another approach has been to machine or form the fluid swirl chamber such that it is spiral in shape, rather than circular, whereby the magnitude of displacement of the axis of rotation of the fluid in the swirl chamber is reduced and more nearly conforms to the axial origin of the spiral, the spray orifice being coaxially positioned with respect to the origin. Both of these approaches are described in U.S. Pat. No. 2,904,263, issued Sept. 15, 1959 to one of the coinventors herein, Roger W. Tate et al. By and large, this spiral swirl chamber approach is effective to provide a spray patternation of satisfactory quality even for the more discriminating uses, so long as the swirl chamber is of relatively large size, for example on the order of 0.30 inch or larger maximum spiral radius. However, where a spray nozzle is desired in which the spiral swirl chamber is relatively small, the spray patternation quality is still unacceptable particularly for the more discriminating uses of the nozzle, since the patternation quality, even of the spiral swirl chamber devices, progressively deteriorates as the swirl chamber radius is decreased. By way of example, it has been found that where the spiral swirl chamber maximum radius is less than 0.20 inch, the patternation index, which is a measure of the distribution pattern quality of the nozzle, generally deteriorates to the point that the spiral chamber nozzles are no longer acceptable for the more discriminating of uses, such as spray drying and fuel injection.

Another approach has been to introduce fluid into the swirl chamber by way of two or more generally tangential, but opposed, fluid inlets, such that the flow of fluid from one of the inlets tends to counterbalance the displacement effect produced by the other of the inlets. This approach has met with limited success, but again it cannot be readily employed in small swirl chamber devices due to space considerations which arise in the smaller devices and the possibility of inlet clogging due to the relatively small dimensions of each of the multiple inlets.

In the present invention, the spiral origin of the spiral swirl chamber and the spray orifice are eccentrically offset relative to each other. It has been found that if the spray orifice and the spiral origin of the spiral swirl chamber are eccentrically offset from each other that not only is spray patternation somewhat improved in the larger forms of spiral swirl chamber devices, but also that the spray patternation is substantially improved in the smaller forms to the point that the smaller forms are acceptable, even in the most discriminating of uses.

Accordingly, in one principal aspect of the invention, a spray nozzle is contemplated of the type which includes a body with a spray orifice, a spiral swirl chamber in the body which communicates with the orifice and a fluid inlet means which communicates with the spiral swirl chamber in substantially tangential relationship. In the invention, the spray orifice and the axial origin of the spiral of the spiral swirl chamber are eccentrically offset relative to each other.

In another principal aspect of the invention, the spray orifice and the spiral origin are eccentrically offset from each other such that the orifice opens to the spiral chamber in a sector thereof between approximately 90° to 150° from the maximum radius of the spiral and in the direction of the fluid rotation in the chamber.

In still another aspect of the invention, the spray orifice and spiral origin are eccentrically offset from each other by a distance of approximately 0.005 to 0.015 inch.

These and other objects, features and advantages of the present invention will be more clearly understood through a consideration of the following detailed description.

BRIEF DESCRIPTION OF THE DRAWING

In the course of this description, reference will frequently be made to the attached drawing in which:

FIG. 1 is a cross-sectioned side elevation view of a spiral swirl chamber nozzle incorporating the principles of the invention;

FIG. 2 is a cross-sectioned end view of the spiral swirl chamber taken substantially along line 2 — 2 of FIG. 1; and

FIG. 3 is a graphic plot of patternation index (PI) v. orifice off-center distance (in.) and showing spray patternation performance curves for varying degrees of orifice angular offset.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a spiral swirl chamber spray nozzle is shown which includes an eccentrically offset spiral swirl chamber and orifice which are positioned relative to each other in accordance with the principles of the invention. In general, the spray nozzle includes a nozzle body **10**, an orifice plate **12** having a spray orifice **13** therein, a swirl chamber block member **14** in which the spiral swirl chamber **16** is formed with a generally tangential inlet **17**, and a retainer member **18** for retaining and positioning the orifice plate and chamber member in the nozzle body **10**.

The nozzle body **10** includes an opening **20** at one end for the emission of spray from the orifice plate **12** and an elongate passage **22** for receiving the various components of the nozzle. A suitable gasket **24** is preferably positioned against a shoulder **25** adjacent the opening **20** and the orifice plate **12** is positioned against the gasket. The swirl chamber member **14** is next positioned against the orifice plate **12** such that one side of the swirl chamber communicates with the spray orifice **13** in the orifice plate, and the retainer member **18**, which is preferably cruciform in shape, is threaded into the nozzle body by way of threads **26** to maintain the gasket, orifice plate, and swirl chamber member positioned as shown in FIG. **1**. The exterior of the nozzle body is also preferably threaded at **28** in order to receive a fluid delivery conduit (not shown) for delivering the fluid to be sprayed to the nozzle body **10**. The flow path of the fluid through the nozzle is shown by the arrows in FIG. **1**, flowing through the cruciform retainer member **18** to the outside of the swirl chamber member **14**, where the fluid passes through the tangential inlet **17** of the swirl chamber **16**, swirls about the spiral swirl chamber, and exits through the orifice **13** in the plate **12** in the form of a finely divided spray.

The spiral swirl chamber nozzle assembly thus far described is of the conventional form. Previously, in this type of spiral chamber nozzle, the axis of the spray orifice **13** is generally positioned to coincide with the axial origin of the swirl chamber, since the spiral form of the swirl chamber, by itself, is relied upon to improve the spray patternation to an acceptable quality as earlier described. In these prior spiral chamber nozzles, either the spray orifice **13** is concentrically located in the center of the circular orifice plate **12** and the entire spiral swirl chamber **16** is machined with a slight offset into the circular chamber member **14**, such that its spiral origin coincides with the concentric orifice, or the spiral swirl chamber **16** was positioned in the center of the chamber member **14** and the orifice **13** is slightly offset in the plate **12** to coincide with the spiral origin of the swirl chamber. Although either method of alignment is acceptable from a performance viewpoint, the former has been generally preferred as it facilitates manufacture and assembly for various reasons.

Although these prior spiral chamber nozzles in which the spiral origin is aligned with the spray orifice result in improved spray patternation over that of the circular swirl chamber nozzles, acceptable patternation for discriminating nozzle uses results only so long as the maximum radius of the spiral can remain relatively large, for example on the order of 0.30 inch or larger. However, where a spiral swirl chamber having a relatively smaller maximum radius is needed, for example on the order of 0.20 inch or less, the provision of a spiral swirl chamber alone is not sufficient to produce an acceptable high quality spray patternation required in discriminating uses, e.g., fuel injection or spray drying.

It has been found that the quality of spray patternation in such spiral swirl chamber nozzles may be improved by eccentrically off-setting the origin of the spiral and the spray orifice relative to each other by a predetermined angle and offset distance and that such eccentric offset results, not only in improved spray patternation in the larger spiral chamber nozzles, but in substantial improvement in the spray patternation of the smaller spiral chamber devices in which the maximum spiral radius is on the order of 0.20 inch or less. In fact, by eccentrically offsetting the spiral origin and orifice as described hereafter, spray patternation quality will actually be improved to the point that the smaller spiral chamber devices become acceptable even in the most discriminating of uses.

Referring to FIG. **2**, a spiral swirl chamber is shown which embodies the principles of the invention. The swirl chamber is formed as a spiral recess **16** which is machined or otherwise formed in the end of the chamber member **14** which is to be positioned adjacent the spray orifice **13**. The depth of the chamber **16** is generally indicated by h in FIG. **1**. The fluid inlet **17** opens substantially tangentially, as in the prior spiral chambers, into the spiral chamber adjacent the beginning of the spiral and the chamber will have a maximum radius r, r being the distance between the spiral origin A and the beginning of the spiral. The chamber **16** itself is separated from the fluid inlet **17** by a tongue-like projection **30** which ends at **32** adjacent r. The distance between the upper wall **34**, of the inlet as viewed in FIG. **2**, and the upper surface **36** of the tongue adjacent end **32** defines the width a of the inlet opening into the chamber, the distance between the wall **34** and the under chamber side of the tongue adjacent end **32** being shown as b in FIG. **2**. Since the swirl chamber **16** is spiral in form, the distance between the spiral origin A and the circumferential wall **40** of the swirl chamber will progressively diminish in a counterclockwise direction from the maximum radius r as viewed in FIG. **2**. Thus, the distance between the spiral origin A and the wall **40** will be such that the distance c will be greater than the distance d and the distance d will be greater than the distance of e as shown in FIG. **2**. The lead or rate of change of the spiral per revolution will be approximately defined by the ratio of r to $(r—b)$, for any one of several various given curvatures.

In accordance with the principles of the invention, the eccentric offset between the spray orifice **13** and the spiral origin A should be such that the center of the orifice **13** lies within a sector of the spiral chamber defined between lines AC and AD and the orifice **13** and spiral origin A should be spaced from each other by the distance x as shown in FIG. **2**. Line AC, which defines the minimum preferred angular offset, is 90° from the radius r in the direction of rotation of the liquid, line AD, which defines the maximum angular offset, is 150° from radius r in the direction of rotation, and the distance x should be between 0.005 and 0.015 inch.

Referring now to FIG. **3**, a plot is shown of patternation index (PI) v. orifice off-center (off-origin) distance (in.) for various angular offsets and for two representative spiral swirl chamber nozzles. Patternation index (PI) is a commonly accepted standard by which spray pattern quality is frequently measured. The PI is determined by employing a multi-sectored testing receptacle device which receives a measured amount of spray from the spray nozzle being tested and which indicates, by sector, the spatial uniformity and distribution of the spray issuing from the nozzle being tested. In general, the lower the PI, the better is the spray distribution or patternation. The method of determining PI will not be discussed in detail herein, since it forms no part of the present invention.

Reference is made to a publication authored by one of the coinventors herein, Tate, R. W. Spray Patternation, Industrial and Engineering Chemistry, Vol. 52, p. 49 A, Oct. 1960, in which the method of determining and the principles of spray patternation are discussed in detail.

In the performance curves of FIG. 3, the patternation results are shown for two spiral chamber nozzles, hereafter referred to as Nozzles I and II, in which certain of the dimensions of the respective chambers were varied. The orifice diameter of the nozzles of FIG. 3 in each instance was the same at 0.040 inch and the fluid was kerosene at an inlet pressure of 200 psig and an ambient temperature of 70° F. Referring to FIGS. 1 and 2, the other dimensions of the spiral swirl chamber nozzles I and II were as follows:

Nozzle	r	a	h	b	c	d	e
I	.150	.060	.040	.090	.128	.106	.084
II	.150	.030	.080	.060	.135	.120	.105

Each of the dimensions above is expressed in inches.

It will be seen when viewing the Nozzle I curves, those shown in solid lines in FIG. 3, that where the spiral origin A and the axis of the spray orifice **13** were coaxially aligned as in the prior concentric spiral chamber devices, a PI of 15 resulted. A PI of more than approximately 8–9 is generally unacceptable in discriminating spray nozzle uses, such as spray drying and fuel injection. However, it will be seen in FIG. 3, that when the spray orifice **13** and the spiral origin A of Nozzle I were eccentrically offset from each other such that distance *x* was equal to approximately 0.005 to 0.015 inches, the PI was substantially improved to the point that it was within the acceptable PI range when the angular offset fell within the 90° to 150° sector range. The greatest improvement was where the angular offset was 120°.

The performance of Nozzle II is shown in the dotted curves in FIG. 3. It will be seen when considering these Nozzle II curves, that PI is also substantially improved by eccentrically offsetting the orifice **13** and the origin A relative to the PI of 30 where the orifice and spiral origin are aligned. More specifically, when the orifice and spiral origin are offset from each other by an angular rotation of 120°, an acceptable PI is realized at a distance *x* of approximately 0.010 inch. It will also be seen that when the angular rotation is increased so as to be substantially greater than 150°, i.e., to 180°, that PI is only slightly improved and not by an acceptable amount.

It will be understood that, as in the prior swirl chamber nozzle devices, the spray orifice **13** and the swirl chamber spiral origin A may be positioned at the desired eccentric offset either by concentrically positioning the orifice **13** in the orifice plate **12** and eccentrically positioning the swirl chamber **16** in the chamber member **14** or vice versa.

It is believed that the reason that spray patternation quality in the concentric spiral swirl chamber devices rapidly deteriorates as the chamber radius becomes smaller is due to a shift in the axis of rotation of the fluid in the chamber as the result of several effects which become more prominent in the smaller chamber nozzles. It is believed that turbulence which, in all probability, occurs at the tongue end **32** where the input fluid and once rotated fluid must merge, combined with the progressive acceleration of the fluid as it rotates around the spiral, the fewer number of times of rotation of a given liquid molecule before discharge, and the wall friction tend to cause the fluid to prefer to rotate about an axis which is slightly offset from the spiral origin A away from the inlet **17**. Thus, if the orifice **13** is eccentrically offset as in the present invention such that it more closely coincides with this new axis of rotation, rather than with the spiral origin A, patternation is improved not only in the larger spiral chamber devices, but by a substantial amount in the smaller spiral chamber nozzles.

It will be understood that the embodiment of the present invention which has been described is merely illustrative of an application of the principles of the invention. Numerous modifications may be made by those skilled in the art without departing from the true spirit and scope of the invention.

What is claimed is:

1. In a spray nozzle having a body with a spray orifice therein, a spiral swirl chamber in said body communicating with said orifice and fluid inlet means communicating with said spiral swirl chamber in substantially tangential relationship thereto, wherein the improvement comprises in combination therewith:
   said spray orifice and the origin of the spiral of said spiral swirl chamber being eccentrically offset relative to each other.

2. In the spray nozzle of claim **1** wherein said spray orifice and said spiral origin are eccentrically offset from each other such that said orifice opens to said spiral chamber in a sector of said spiral swirl chamber of between approximately 90° to 150° from the maximum radius of said spiral adjacent said fluid inlet and in the direction of fluid rotation in said chamber.

3. In the spray nozzle of claim **2** wherein said spray orifice and said spiral origin are eccentrically offset from each other by a distance of approximately 0.005 to 0.015 in.

4. In the spray nozzle of claim **3** wherein said maximum spiral radius is less than approximately 0.20 in.

5. In the spray nozzle of claim **1** wherein said spray orifice and said spiral origin are eccentrically offset from each other by a distance of approximately 0.005 to 0.015 in.

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