LIQUID DISCHARGE NOZZLE HAVING IMPROVED FLOW CONTROL MEANS

Inventors: John O. Hruby, Jr., Burbank, Calif.; Rain Jet Corp., Los Angeles, Calif.

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References Cited

UNITED STATES PATENTS

259,667 6/1882 Churchman 239/552
748,608 1/1904 Hueni 239/552
2,121,948 6/1938 Borland 239/552

FOREIGN PATENTS OR APPLICATIONS

3,556,410 1/1971 Arant 239/552
173,901 1/1922 Great Britain 239/552
389,097 6/1908 France 239/552

Primary Examiner—Lloyd L. King
Attorney—Christie, Parker & Hale

ABSTRACT

A family of aerating liquid discharge nozzles, each having an elongate body defining a duct therethrough between lower and upper liquid inlet openings defined at opposite ends of the body, is described. A plug is disposed across the duct and has liquid flow passage means defined therethrough by a plurality of grooves formed in the plug sidewalls. The grooves are spaced uniformly around the circumference of the plug and have an aggregate cross-sectional area substantially less than the cross-sectional area of the duct at the location of the plug in the duct. A conical projection extends from the plug toward the liquid inlet opening coaxially of the duct, the radius of the projection, at its base, being at least equal to the minimum radius of the plug.

15 Claims, 13 Drawing Figures
CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of copending application Ser. No. 784,541, filed Dec. 9, 1968 (now U.S. Pat. No. 3,558,593) and a continuation-in-part of now abandoned application Ser. No. 691,111, filed Dec. 8, 1967 as a continuation-in-part of now abandoned application Ser. No. 492,389, filed Oct. 4, 1965.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to liquid handling and, more particularly, to nozzles for discharging aerated liquid in a predetermined pattern. Nozzles according to this invention are characterized by the absence of moving parts in the liquid stream.

2. Description of the Prior Art

In ornamental fountain arrangements which are to be viewed during the day without illumination by artificial light, it is desired that the discharged water be aerated as fully as possible in order that the water discharge pattern may be readily visible. Aerating fountain heads or nozzles are known, but produce only a limited number of water discharge patterns. Many existing aerated fountain heads do not produce sufficient aeration of the water discharged from them. Moreover, many existing aerating nozzles contain moving parts which wear as the nozzle is operated. In other cases, existing aerating nozzles require critical clearances in the nozzle openings to produce the desired aeration; these clearances either become worn by erosion as the nozzle is operated, or clogged by foreign particles in the liquid passing through the nozzle head, thus adversely affecting the nozzle aerating efficiency.

For efficiency of operation, an aerating fountain nozzle should produce the appearance of discharging a massive stream of water even though the quantity of water actually passed through the nozzle is relatively moderate. When this desired condition is obtained, a small pump may be used, thus resulting in a fountain which is economical to operate. Also, in order that they may be used in populated areas, aerating fountain nozzles should produce as little mist or fine spray as possible; mist is readily transported by light breeze or rain out of the fountain area to locations where viewers may be positioned. Mist also tends to mask the basic fountain discharge pattern and thus detracts from the aesthetic effect desired in the fountain.

The design of aerating liquid nozzles is often more of an art than a science, especially where it is desired that the aerated liquid discharged from the nozzle follow a predetermined path from the nozzle throughout a relatively wide range of liquid pressures applied to the nozzle, and where the discharge is to be used to produce an ornamental effect. The use of techniques and principles which are effective in gas mixing nozzles, wherein two or more gases are mixed in the nozzle structure and are discharged as a mixture, is practical in only random situations in aerating liquid nozzles because of the widely different physical properties between gases and liquids.

SUMMARY OF THE INVENTION

This invention provides a simple, rugged, effective and efficient aerating nozzle which is particularly useful in ornamental fountain arrangements. The nozzle contains no moving parts which may wear as the nozzle is operated. Moreover, no critically sized apertures are provided in the nozzle, and thus water erosion and the presence of foreign particles in the water passed through the nozzle have little effect, if any, upon the aerating efficiency of the nozzle. The nozzle produces the appearance of a massive discharge stream even though the actual volume of water passed there through is moderate. Moreover, nozzles according to this invention preferably provide a straight stream discharge which is unusually smooth and essentially free of objectionable mist or fine spray, and which is readily visible because of the high degree of aeration of the nozzle discharge and freedom from mist.

Generally speaking, the invention provides an aerating liquid discharge nozzle which includes an elongate body defining a duct between a liquid inlet opening and a liquid outlet opening located at opposite ends of the body. A plug, having substantial length between its opposite end surfaces relative to the diameter of the duct, is disposed across the duct adjacent the duct outlet opening. The duct inlet opening has an area which is at least as great as the effective cross-sectional area of the duct at the location of the plug along the duct. The plug defines liquid passage means through it, such passage means being comprised of a plurality of grooves formed in the plug sidewalls, the grooves being spaced uniformly around the circumference of the plug. The liquid passage means has a cross-sectional area, at least adjacent the other end of the body, which is substantially less than the cross-sectional area of the duct at the location of the plug in the duct. A conical projection extends from the plug toward the liquid inlet opening coaxially of the duct, the radius of the projection, at its base, being at least equal to the minimum radius of the plug; the minimum radius of the plug is the distance from the axis of the duct to the limits of the grooves most adjacent the duct axis.

The liquid discharge nozzles of the present invention may be used to great advantage to produce an aerated discharge of essentially straight line characteristics which is smooth and coherent, not ragged, and is capable of carrying objects when directed upwardly. Specifically, the conical projection substantially reduces turbulence generated in the duct by liquid flowing from the inlet opening toward the plug. Without such projection, turbulence generated by liquid impinging on the solid portion of the plug inlet end would produce a ragged discharge with a decreased maximum attainable height. The conical projection serves to guide incoming liquid toward the grooves in the plug sidewalls since the radius of the projection, at its base, at least equals the minimum radius of the plug adjacent such base. Furthermore, since the open area in the duct laterally adjacent the conical projection decreased from the apex of the projection to the base thereof, the velocity of the liquid passing through the grooves is increased thereby increasing the maximum attainable discharge height. The projection function conserves the energy of liquid supplied to the nozzle so that the nozzle performs efficiently to produce a liquid discharge of great height relative to the power of the pump used to supply liquid to the nozzle and relative to the quantity of liquid passed by the nozzle.

BRIEF DESCRIPTION OF THE DRAWING

These and other aspects and advantages of the present invention are more clearly described with reference to the accompanying drawing in which:

FIG. 1 is a cross-sectional elevation view of one liquid discharge nozzle according to the present invention, such view being taken along the lines 1—1 of FIG. 2;
FIG. 2 is a top plan view of the nozzle of FIG. 1;
FIG. 3 is a perspective view of the plug insert of FIGS. 1 and 2;
FIG. 4 is a cross-sectional elevation view of another liquid discharge nozzle according to the present invention taken along lines 4—4 of FIG. 5;
FIG. 5 is a top plan view of the nozzle of FIG. 4;
FIG. 6 is a perspective view of the plug insert of the nozzles of FIGS. 4 and 5;
FIG. 7 is a cross-sectional elevation view of yet another liquid discharge nozzle according to the present invention taken along lines 7—7 of FIG. 8;
FIG. 8 is a top plan view of the nozzle of FIG. 7;
FIG. 9 is a perspective view of the plug insert of the nozzle of FIGS. 7 and 8;
FIG. 10 is a fragmentary cross-sectional elevation view of still another liquid discharge nozzle according to the present invention;
FIG. 11 is a top plan view of the nozzle of FIG. 10;
FIG. 12 is a cross-sectional view of the nozzle of FIGS. 10 and 11 taken along lines 12—12 of FIG. 10; and
FIG. 13 is a cross-sectional view of yet another liquid discharge nozzle according to the present invention.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

A liquid discharge nozzle 10, which is particularly useful in aerated discharge ornamental fountains and shown in FIGS. 1-3, includes an elongate, straight, hollow tubular body 12 defining an elongate, circularly cylindrical ductlike chamber 14 therethrough. The body has an internally threaded open lower end 16 to adapt the body to be securely connected to a suitably sized water discharge pipe or the like through which water at suitable pressure is supplied to the nozzle. The lower end of the body defines a liquid inlet opening to duct 14. The cylinder, defined by the inner wall of the body, is open across its entire extent at an open upper end 18 of the body.

A plug 20, having substantial length between opposite ends thereof relative to the inner diameter of the body, is disposed across duct 14 adjacent the outlet opening of the duct with its sidewalls 21 in intimate engagement with the inner walls of the body. In nozzle 10, as in all nozzles according to this invention, the area of the liquid inlet opening to the duct is at least as great as the effective cross-sectional area of the duct at the location of the plug along the duct.

Liquid flow passage means are formed through plug 20 parallel to the axis of the body and have an aggregate cross-sectional area, at least adjacent the outlet end of the body, substantially less than the cross-sectional area of duct 14 at the location of the plug along the duct. As best shown in FIG. 2, the liquid flow passage means is defined by a plurality of circularly circularly cylindrical elongate grooves 22 formed in the sidewalls 21 of plug 20 along a chord uniformly around the entire circumference of the plug. As with the other nozzles described hereinafter, nozzle 10 is devoid of any structure spanning duct 14 downstream of plug 20. In other words, after liquid passes through grooves 22 in plug 20, it does not pass through any additional structure, other than the body itself, in emerging from the nozzle. Nozzle 10 is defined with the upper end of the plug flush with outlet end 18 of the body.

A conical-shaped projection 24 extends from plug 20 toward the liquid inlet opening 16 coaxially of the duct. Projection 24 has a base 26 and an apex 27 which is preferably rounded for added strength. The taper of projection 24, as measured by included angle δ, is preferably between 30° and 60°, this being true of all of the conical projections of the nozzles according to the present invention. The radius of projection 24, measured at its base 26, is at least equal to the minimum radius of plug 20 at such base. The minimum radius of plug 20 at projection base 26 is defined as the distance from the longitudinal axis of the duct to the point on each of grooves 22 most adjacent the duct axis.

The purpose of conical projection 24 is to reduce turbulence normally created by liquid flowing against the inlet side of plug 20. If projection 24 were not included in the design of plug 20, incoming liquid would strike the total area of an inlet side 26 of the plug, of which only a minor portion is open at grooves 22. When striking the solid portion of the plug inlet end, liquid is reflected back upstream, thereby creating turbulence in the liquid flow adjacent plug inlet side 26. The presence of turbulence reduces the energy present in liquid supplied to the nozzle. Projection 24 substantially reduces turbulence by guiding incoming liquid directly to grooves 22 in the plug sidewalls, thereby bypassing most of the solid portion of inlet side 26 of the plug.

In addition to reducing turbulence, conical projection 24 effects an increase in the velocity of liquid flowing through grooves 22 since the maximum transverse cross-sectional area of the projection is at the inlet to the grooves, i.e., at the projection base 26. The increased velocity is manifest in a higher discharge stream.

As shown, it is preferred that the upper end surface 25 of plug 20, at least around the upper ends of grooves 22, be essentially normal to the length of the adjacent groove to define a sharp corner from which liquid emerging from the groove separates cleanly. This feature of nozzle 10 is encountered in all other nozzles shown in the drawings and described herein, and is desirable to eliminate, to the greatest extent possible, the presence of mist or fog in the nozzle discharge pattern. Also, as shown with respect to all nozzle described, it is preferred that the upper end 18 of body 10 be defined by a surface which is normal to the axis of duct 14, for the same reason. Because the grooves of plug 20 are parallel to the axis of duct 14, the top surface 25 of plug 20 conveniently may be made flat and perpendicular to the length of the plug.

FIGS. 4-6 show another aerating liquid discharge nozzle 28 which is identical with nozzle 10 in terms of the design and configuration of tubular body 12 and duct 14. The major structural difference between nozzles 10 and 28 relates to the configuration of a plug insert 30 disposed across duct 14 adjacent outlet opening 18; as shown, the upper end of plug 30 is flush with the upper end of body tube 12. Liquid flow passage means are formed through plug 30 by means of three grooves 32 defined in the sidewalls 34 thereof parallel to the axis of duct 14 and spaced uniformly about the circumference of the plug. Adjacent grooves are separated by one of three longitudinally extending rib members 35 projecting laterally outward from a base surface 36 of the grooves. Each member 35 defines a portion of the plug sidewalk 34 which is intimately engaged with the inner wall 37 of the body to support the plug in the body. The base surface 36 of each of grooves 32 is flattened parallel to the plug axis and is disposed radially inwardly of plug sidewalk 34.

A conical projection 38, similar in design, purpose and effect to projection 24 of nozzle 10, extends from plug 30 toward liquid inlet opening 16 coaxially of duct 14. As with projection 24, the radius of projection 38, measured at its base 40, is at least equal to the minimum radius of plug 20 at such base. Here, the minimum radius is defined as the distance from the axis of duct 14 to the points on flattened surfaces 36 of grooves 32 most adjacent the duct axis (see FIG. 6). Projection 38 serves to guide incoming fluid about and past its rounded apex 42 and directly toward grooves 32 so that turbulence created adjacent the plug, for the reasons above described, is substantially reduced. Thus, a coherent and essentially smooth stream is discharged from the nozzle with an increased velocity relative to the velocity of the liquid at inlet end 16 of the nozzle.

It is to be noted that turbulence generated by liquid flowing against the inlet side of plug 30 is less than that generated in nozzle 10, notwithstanding the substantial reduction of turbulence in both nozzles 10 and 28 by conical projections 24 and 38, respectively. The reason is due to the decreased solid area of plug 30 separating the spaced grooves and represented by members 35. In other words, cone 34 guides liquid to a lesser blocked area than does cone 24 of nozzle 10.

Another aerating liquid discharge nozzle 44, embodying the principles of the present invention, is shown in FIGS. 7-9. As with nozzle 28, the only difference between nozzle 44 and nozzle 10 resides in the structure of the plug insert. Thus, a plug 46, having substantial length between opposite ends thereof relative to the inner diameter of body 12, is disposed across duct 14 adjacent outlet opening 18 of the body, preferably with its upper end surface flush with the upper end of the body.

Liquid flow passage means are formed through plug 46 by a plurality of circularly cylindrical grooves 48 defined in the sidewalls 50 of the plug. The grooves are spaced uniformly about the circumference of the plug with adjacent grooves intersecting each other at the plug sidewalls 50. The maximum radius of the plug is less than radius of the inner wall 52 of the body. Thus, no portion of the plug sidewalls, defined at the intersections between grooves 48, are engaged with the inner walls of the body. A nonrestricted liquid flow passage is thus defined through the plug entirely about its outer periphery. The manner of engaging the plug with inner walls 52 is that the plug will remain fixed within body 12 and is explained below.
A conical projection 54, similar in design and function to conical projections 24 and 38, extends from plug 46 toward liquid inlet opening 16 coaxially of duct 14. As with projections 24 and 38, the radius of projection 54, at its base 56, is at least equal to the minimum radius of the plug at such base. Unlike nozzles 10 and 28, grooves 48 do not end precisely at the base of the conical projection. In nozzle 44, the grooves are extended into conical projection 54 so as to terminate at points on the outer surface of the projection. That is, the basal radius of projection 54 is equal to the maximum radius of plug 46. The fact that the grooves are extended into the conical projection aids in the reduction of turbulence and in the smooth transfer of fluid through the plug.

A plurality of liquid flow path straightening members 58, of finlike configuration, are spaced uniformly about the outer surface of projection 54. In nozzle 44, there are 3 such members 58 spaced 120° apart. Each member 58 performs two functions. First, it provides a straighter discharge stream from the nozzle by guiding liquid along its side surfaces 60 which are disposed parallel to the longitudinal extent of the plug. Additionally, it serves to fix the plug in the duct by engaging the inner walls 52 of the plug at their ends 62 most remote from the axis of the plug.

The liquid discharged from nozzle 44 is thus in the form of an unusually straight elongate stream which is very smooth due to the reduction of turbulence within the duct. In other words, conical projection 54 guides liquid from projection 54 and past its rounded apex toward and through the total nonrestricted flow path defined by grooves 48. There are no body inner wall engaging members to cause turbulence, however slight, as members 35 of nozzle 28. As in nozzles 10 and 28, conical projection 54 increases liquid velocity from plug inlet to outlet thereby increasing the maximum possible discharge height.

Still another aerating liquid discharge nozzle 64, in accordance with the principles of the present invention, is shown in FIGS. 10–12. As before, body 12 and duct 14 are identical with those of the previously discussed nozzles; only the plug insert being different. Thus, a plug 66 is disposed across duct 14 adjacent and preferably somewhat below outlet opening 18 thereof, the plug having substantial length between opposite ends thereof relative to the diameter of the duct.

Liquid flow passage means are formed through the plug by a plurality of grooves 68 similar in design to grooves 48 in plug 46, grooves 68 being defined in the sidewalls 70 of the plug parallel to the axis of duct 14. In plug 66, however, as opposed to plug 46, the sidewalls of the plug are engaged with the inner walls 72 of the body. This engagement provides the means for fixing the position of plug 66 within duct 14. In plug 46, such was accomplished by straighteners 58.

As with grooves 48 of plug 46, grooves 68 extended into a conical projection 74 at a point below its base. The projection is substantially identical with conical projection 54 of plug 46 and extends from plug 66 toward liquid inlet opening 16. The radius of projection 74, as its base, is equal to the maximum radius of the plug. Extension of grooves 68 into projection 74 facilitates the flow of liquid through the plug and further reduces turbulence.

A plurality of liquid flow straighteners 76 are engaged about the outer surface of projection 74. The maximum extent of each straightener radially from the duct axis is less than the radius of the duct. Thus, straighteners 76 perform only a liquid straightening function in order to provide a straighter elongate fluid discharge. They do not serve to fixedly engage the plug within the duct since that is accomplished by the engagement of plug sidewalks 70 with body inner walls 72. The resultant discharge from nozzle 64 is substantially the same as from nozzle 44 and has all the beneficial features achieved by the latter. In other words, the discharge is essentially smooth and can attain maximum lengths because of the operative effect of conical portion 74.

It is to be noted, that the height and width of the fluid discharge from any of the nozzles, according to the present invention, may be varied by varying the position of the insert plug in the duct. Thus, the outlet end of the plug need not be flush with duct outlet opening 18, as in nozzles 10, 28 and 44. The plug insert may be recessed below opening 18, as is shown by plug 66 of nozzle 64.

The discharge height may also be controlled by tapering the grooves in the plug defining the liquid flow passage means. For instance, the velocity of liquid discharge from nozzle 10 may be increased by tapering grooves 22 so that the maximum cross-sectional area transverse of each groove is adjacent the inlet end of the plug and the minimum transverse cross-sectional area is adjacent the outlet end of the plug. A greater discharge velocity produces a greater height. Such a tapered effect to grooves 22 is shown in FIG. 13 by a nozzle 78 substantially identical with nozzle 10, but having grooves 80 defined in a plug 82, tapered in the manner above described. It is to be noted that if it were desirable to decrease velocity of the liquid discharged relative to its incoming velocity into the plug, the grooves could be tapered so as to increase in transverse cross section toward the outlet end of the plug.

In each of the nozzles described above, each of the plugs is of substantial length relative to the diameter of the duct in which the plug is disposed. Preferably, the portion of the plug in which the grooves are defined is approximately as long as or longer than the diameter of the duct. In this respect, the plugs are at least "square" in terms of length to diameter ratio. Also, the grooves are at least twice as long as they are deep radially of the nozzle; preferably the grooves are several times longer than they are deep.

Because liquid emerges from each of the nozzles described above around the periphery of the nozzle instead of as a single stream coaxially of the nozzle, the discharge patterns produced by these nozzles is relatively massive in appearance and appears to be defined by a much greater quantity of liquid than is actually the case.

What has been described, therefore, is a family of aerating liquid discharge nozzles, each of which includes means for providing a straight elongate stream of liquid having an essentially smooth and coherent characteristic, and which can achieve maximum possible heights when discharging liquid upwardly therefrom. Such a liquid discharge, as is produced by each of the nozzles above described, is especially useful in ornamental fountains or the like.

What is claimed is:

1. A liquid discharge nozzle for discharging liquid generally upwardly therefrom comprising:
   a. an elongate straight body defining a duct therethrough between a lower liquid inlet opening defined at an open lower end of the body and an upper liquid outlet opening defined across an open upper end of the body;
   b. a plug having substantial length between opposite ends thereof relative to the duct disposed across the duct adjacent the duct outlet opening, the duct inlet opening having an area at least as great as the effective cross-sectional area of the duct at the location of the plug along the duct;
   c. liquid flow passage means defined through the plug by a plurality of grooves formed in the sidewalks of the plug at locations spaced uniformly around the circumference of the plug, the liquid flow passage means having a total cross-sectional area, at least adjacent the outlet end of the body, substantially less than the cross-sectional area of the duct at the location of the plug in the duct; and
   d. a conical projection extending from the plug toward the liquid inlet opening coaxially of the duct, the radius of the projection at its base being at least equal to the minimum radius of the plug at the projection base.

2. The nozzle of claim 1, wherein each of the grooves extends from the end of the plug adjacent the liquid outlet opening to the end of the plug from which the projection extends.

3. The nozzle of claim 1, wherein each of the grooves extends from the end of the plug adjacent the liquid outlet opening into the conical projection.
4. The nozzle of claim 3, wherein the grooves are tapered from a maximum transverse dimension at the end of the plug adjacent the liquid outlet opening to a minimum transverse dimension in the conical projection.

5. The nozzle of claim 1, further comprising a plurality of liquid flow-path straightening members each having an inner extent defined in the plug and an outer extent adjacent the inner walls of the duct, the members being spacially located about the plug.

6. The nozzle of claim 5, wherein the outer extent of each straightening member is engaged with the inner walls of the duct.

7. The nozzle of claim 1, further comprising a plurality of liquid flow-path straightening members each having an inner extent defined in the conical projection and an outer surface adjacent the inner walls of the duct, the members being spacially located about the plug.

8. The nozzle of claim 7, wherein the outer extent of each straightening member is engaged with the inner walls of the duct.

9. The nozzle of claim 1, wherein the grooves constitute the only liquid flow passages communicating between the opposite ends of the plug.

10. The nozzle of claim 1, wherein the nozzle is devoid of structure spanning the duct between the plug and the outlet end of the duct.

11. The nozzle of claim 1, wherein the end of the plug adjacent the liquid outlet opening is essentially coplanar with the outlet end of the duct.

12. The nozzle of claim 1, wherein the conical projection has a rounded apex.

13. The nozzle of claim 1, wherein the conical projection has a radius, at its base, exactly equal to the minimum radius of the plug adjacent the projection base.

14. The nozzle of claim 1, wherein the grooves have sidewalls which intersect the plug sidewalls.

15. The nozzle of claim 1, wherein the grooves are parallel to the axis of the duct at the location of the plug in the duct.