A water discharge nozzle has particular utility as a fountain nozzle in situations where the water supply to the nozzle has solid matter entrained therein. The nozzle includes an elongate tubular body which has outlet and inlet openings across opposite ends thereof. Annular plug means are disposed in the body adjacent the outlet opening and are engaged about their circumference in intimate engagement with the inner walls of the body. The plug means define a single passage therethrough, the passage being composed of a substantially circular hole which extends from the apex of substantially conical recess in that end of the plug which is located adjacent the inlet opening. The recess is concave to the inlet opening. A plurality of flutes are formed in the walls of the hole and extend with the hole from the recess to the end of the plug means located adjacent the outlet opening. Each flute has opposing wall surfaces disposed in non-diverging relation proceeding radially away from the hole axis.

19 Claims, 7 Drawing Figures
NOZZLE FOR DISCHARGING LIQUIDS CONTAINING SOLID MATTER

REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of copending application Ser. No. 87,886 filed Nov. 9, 1970 now U.S. Patent No. 3,705,686, of copending application Ser. No. 242,663 filed Apr. 10, 1972, and of copending application Ser. No. 304,244 filed Nov. 6, 1972.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to water discharge nozzles, and more particularly to nozzles adapted for discharging water having solid matter entrained therein, which nozzles are especially useful in fountains installed in lakes and ponds, for example.

2. Description of the Prior Art

Commonly-owned U.S. Patent Nos. 3,330,486, 3,447,749, 3,558,053, 3,602,434, 3,612,396, 3,630,443, 3,640,472 and 3,645,449, for example, describe water discharge nozzles which are useful in generating the aesthetically appealing water discharge patterns found in ornamental fountains. These nozzles produce desired fountain discharge patterns by flow of water through passages and apertures defined in the nozzle structure. The aesthetic properties of the particular discharge pattern are determined by the shape, size and disposition of the passages and apertures in the respective nozzle structure. The presence of solid matter in water supplied to these nozzles may result in plugging or clogging, in whole or in part, of some or all of the passages and apertures in the particular nozzle, thereby having an unpleasing adverse effect upon the nozzle discharge pattern.

The nozzles described in the above-mentioned patents may be used to advantage without significant adverse effect in conventional fountains where the water supplied to the fountain nozzle is purified water of much the same character as is obtained from municipal drinking water lines and the like. In fact, it is conventional to operate fountains, whether including structures according to the foregoing patents or not, on such purified water. Such purified water does not contain sufficient solid matter to have an adverse effect upon these nozzle structures.

It is becoming more and more common to install fountains in lakes, ponds or the like for purely ornamental effects or for both ornamental and other utilitarian effects, such as aeration of the discharged water. Fountains located in these lakes may be of either the floating or non-floating variety. In many cases, the water supplied to the fountain nozzle is drawn from the lake itself and may contain substantial solid matter such as leaves, small fish, moss, twigs and the like. The nozzle structures defined in the patents listed above may be used in lake fountains and the like if the fountain assembly includes suitable strainers or filters to remove any entrained solid matter from the water stream before the water reaches those orifices and passages in the nozzle structure which define the fountain discharge pattern. The use of a strainer or filter, however, requires that the fountain be serviced at intervals determined by the nature and extent to which large size solid matter is present in the water supplied to the fountain assembly. In some cases, the raw water supplied to the fountain assembly includes sufficient solid matter that the types of strainers required for successful operation of previously known fountain nozzles may require service on a daily basis. The need to service and clean filters and the like is an economic burden associated with the operation of a fountain and should be minimized wherever possible. Also, the presence of a strainer or filter in a fountain assembly is an added element of cost in the fountain installation.

A need exists, therefore, for fountain nozzle structures which can operate successfully to produce the desired ornamental fountain discharge patterns even where the water supplied to the nozzle structure contains substantial entrained solid matter. The existence of such nozzle structures makes possible the use of strainerless fountain assemblies which may be used to advantage in lakes, ponds or the like where the fountain operating water is raw water drawn from the lake itself.

SUMMARY OF THE INVENTION

This invention provides novel, efficient, economical and effective nozzle structures for discharging water having solid matter entrained therein. The present nozzle structures are arranged so that any entrained solid matter presented to the nozzle is passed through the nozzle and is not retained by the nozzle to clog the water flow passages or apertures therein. Such a nozzle has particular utility in a fountain assembly disposed in a lake for use with water drawn from the lake itself and supplied directly to the nozzle structure without first passing through a strainer or the like. Such nozzles have other areas of utility such as in sewage treatment plants where they may be used for preliminary aeration of raw sewage, for example.

Generally speaking, this invention provides a water discharge nozzle which includes an elongate tubular body having an outlet opening across one edge thereof and an inlet opening across the other end thereof. Annular plug means are disposed in the body adjacent the outlet opening in spaced relation to the inlet opening and are engaged about their circumference in intimate engagement with the inner walls of the body. The plug means define a single passage therethrough. The passage is composed of a substantially circular hole which extends from the apex of a substantially conical recess in the end of the plug means adjacent the inlet opening. The recess is concave to the inlet opening. A plurality of flutes are formed in the walls of the hole and extend with the hole from the recess to the end of the plug means disposed adjacent the outlet opening. Each flute has opposing wall surfaces disposed in non-diverging relation proceeding radially away from the hole axis.

DESCRIPTION OF THE DRAWINGS

The above-mentioned and other features of this invention are more fully set forth in the following detailed description of presently preferred embodiments of this invention, which description is presented with reference to the accompanying drawings, wherein:

FIG. 1 is an elevation view, partially in cross-section, of a nozzle according to this invention;

FIG. 2 is a plan view taken along line 2-2 in FIG. 1;

FIG. 3 is a fragmentary cross-sectional elevation view of another water discharge nozzle;

FIG. 4 is a fragmentary elevation view of still another water discharge nozzle.
FIG. 5 is a cross-sectional elevation view of a fountain assembly in which the nozzles shown in FIGS. 1, 2 and 3 may be used to advantage; FIG. 6 is a fragmentary view taken along line 6—6 in FIG. 5; and FIG. 7 is a cross-sectional view taken along line 7—7 in FIG. 5.

DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

A water discharge nozzle 10 (see FIG. 1) includes an elongate, straight, tubular body 11 having open lower and upper ends 12 and 13, respectively. The open ends of the body define water inlet and water outlet openings to and from a duct 14 which extends through the length of the body. Preferably, body 11 is fabricated of a suitable length of polyvinyl chloride pipe of desired diameter. The body is adapted adjacent its lower end, as by external threads 15, to be secured to a suitable source of water to be discharged. As shown in FIG. 5, the water source for the nozzle may be a fountain base.

An elongate annular plug 16 is disposed within body 11 adjacent the outlet opening from the body. As shown in FIG. 1, in nozzle 10 plug 16 is disposed wholly within the length of the body, but it is within the scope of this invention that some portion of the plug may be disposed outwardly of the body upper end, if desired. The plug has substantial length in the body relative to the mean transverse dimension of duct 14 and is at least as long between its opposite ends 17 and 18 as the inner diameter of the body; preferably plug 16 has a length which is greater than its outer diameter. The plug preferably is force fitted into the interior of body 11 so that the outer walls 19 of the plug are intimately engaged with the walls of duct 14 along the length of the plug. In this manner, the plug is effectively sealed to the body so that no water flow exists between the body and the plug.

A single water flow passage 20 is defined through the plug coaxially of body 11. The passage is composed of a circular hole 21 (see FIG. 2 where the hole is represented in broken lines) which extends upwardly through the plug from the apex of a conical recess 22 formed in the plug bottom surface 17. A plurality of flutes 23 are formed in the walls of hole 21 and extend with the hole from the recess to the upper end of the plug. Each recess has opposing wall surfaces 24 which are disposed in non-diverging relationship proceeding radially away from the axis of passage 20. Each flute has a depth radially of the plug which is at least as great as the width of the flute between wall surfaces 24. Preferably, the depth of each flute is at least equal to the radius of hole 21. Preferably, as shown in FIG. 2, wall surfaces 24 are disposed parallel to each other, but it is within the scope of this invention that these wall surfaces may converge toward each other proceeding toward the circumference of the plug. Also, each flute has an end surface 25 which preferably is semicircularly contoured concave to the axis of the passage. In a preferred nozzle 10, flutes 23 are defined in a plug of polyvinyl chloride using a ball end mill to define the flutes in the walls of a previously drilled circular hole through the plug.

Each flute has an axis 26 which is illustrated in broken lines in FIG. 1, at the center of curvature of flute end surface 25. In nozzle 10, flute axes 26 converge toward each other proceeding upwardly along passage 20 from recess 22. This relationship between the flute axes and the passage axis is referred to as a positive taper angle, and preferably the taper angle 27 of flutes 23 is in the range of from 2° to 5 degrees.

As best shown in FIG. 2, flutes 23 are spaced uniformly about the circumference of hole 21. Preferably the flutes are so formed in the walls of the hole such that adjacent wall surfaces 24 of adjacent grooves intersect each other at the hole and are not spaced from each other about the circumference of the hole. That is, adjacent grooves 23 are contiguous to each other at the circumference of hole 21.

It is preferred that the half-angle, (one-half the included angle at the apex of conical recess 22) of the conical recess be in the range of from about 30 degrees to about 45°, and for best practice of the invention, the value of this half-angle is toward the lower end of this range.

Nozzle 10 is particularly well suited for use in a fountain located in a lake or the like, and in which the water supplied to the nozzle contains entrained solid matter such as leaves, small fish or the like, as is the case where the water supplied to the fountain is taken from the lake itself. Any solid matter of sufficiently small size that it can be captured in the water stream supplied to the nozzle is passed through the nozzle structure itself and is not caught or retained by the nozzle. Inasmuch as the diameter of conical recess 22 at the lower end of plug 16 is essentially equal to the diameter of the plug, solid matter is not entrained by a shoulder formed in the lower end of the plug. Also, the conical recess directs water approaching the lower end of the plug to flow substantially along the axis of duct 14 so that entrained solid matter is contained within that portion of the discharge stream which flows along hole 21. Flutes 23 are provided to impart the desired definition to the discharge stream from nozzle 10.

FIG. 3 shows another nozzle 30 which is similar to nozzle 10 except that plug 31 of nozzle 30 defines a single liquid flow passage through the plug in which flutes 32 have axes 33 disposed parallel to the axis of duct 14. In nozzle 35 (see FIG. 4), a single liquid flow passage through plug 36 is defined so that flutes 37 have axes 38 inclined to the axis of duct 14 to diverge from each other proceeding toward the upper end surface of the plug. Taper angle of divergence 39 of flute axes 38 preferably is in the range of from 2° to 5°. In the case of nozzle 35, flutes 37 have a negative taper in that the cross-sectional area of the passage above recess 32 increases proceeding in the direction of water flow through the nozzle.

Nozzles 10, 30 and 35 all have different water discharge characteristics and can be used to advantage to define fountain discharge patterns of different aesthetic characteristics. Within either of nozzles 10 or 35, it has been found that a variation of the taper angles, 27 and 39 respectively, also has an effect upon the aesthetic characteristics of the discharge pattern. As mentioned above, nozzles 10, 30 and 35 may be used to advantage in floating fountain assemblies located in the lake of a park or a golf course, for example. This is illustrated in FIG. 5, which depicts a floating fountain assembly 40 which, in effect, includes nozzle 30 as a component thereof by virtue of the use of plug 31 as an element of a discharge nozzle 42 which is mounted to a support base 41. The support base and nozzle assembly are coaxially aligned along an axis 43.
of the fountain assembly. It will be understood that, if desired, plug 16 or plug 36 could be included as components of nozzle assembly 42, depending upon the particular water discharge characteristics desired in the fountain.

Nozzle base 41 is composed of a body 44 and a cover plate 45 which cooperate to enclose a chamber 46 formed coaxially of the fountain assembly. The chamber is of substantially right circular configuration and has diametrically opposed inlet openings formed through the side walls of the body adjacent the floor of the cavity. The inlet openings are defined by corresponding ones of a pair of connection nipples 48 engaged through the body side walls. Suitable water supply conduits are connected to the outer ends of the connection nipples as more fully explained in copending U.S. Pat. No. 3,705,686. A plurality of light and float support arms 49 have their inner ends engaged within corresponding recesses 50 formed in the exterior of the body side walls at regularly spaced intervals around the circumference of the body. The inner ends of the light and float support arms are maintained within recesses 50, and connection nipples 48 are retained within the body, by being diametrically traversed by corresponding ones of a plurality of through-bolts 51 which extend vertically through the body side walls and the rim of cover plate 45, as shown in FIG. 5. Suitable floats (not shown, but see copending application Ser. No. 304,244 filed Nov. 6, 1972) may be connected to the remote ends of arms 49 for buoyantly supporting the fountain assembly in a vertical attitude in a lake or the like with the upper extent of the nozzle assembly located above the water surface.

Nozzle assembly 42 includes a central elongate tubular body 53 which is substantially identical to body 11 of nozzle 10, for example, except for the presence in body 53 of a plurality of holes 54 formed through the body intermediate its length. Body 53 is connected, as by threading or solvent welding, to the boundaries of a chamber outlet opening 55 formed coaxially of the chamber through cover plate 45. Plug 31 is disposed, as described above, in the upper end of body 53. An outer tubular member 56 is disposed concentrically about body 53 and is mounted to body 53 by upper and lower annular closure members 57 and 58 respectively. Upper closure member 57 is disposed partially out of the upper end of tubular member 56. In this manner, an annular chamber 59 is formed about the circumference of body 53 and is communicated to the interior of body 53 by holes 54. A plurality of water discharge passages are formed through upper closure member 57 in such manner as to discharge water from chamber 59 in a desired manner. In nozzle assembly 42, the discharge passages are formed by corresponding ones of a plurality of grooves 60 formed in the circumference of upper closure member 57 at regularly spaced intervals about axis 43. Grooves 60 have opposing parallel wall surfaces 61 (see FIG. 6) and are tapered so that the cross-sectional area of the grooves increases proceeding upwardly along axis 43 in the nozzle assembly.

In operation, fountain assembly 40 produces a discharge pattern which is composed of a central axial stream of aerated water discharged through plug 31, and by a plurality of upwardly diverging discrete un aerated water streams discharged through corresponding grooves 60. In the fountain assembly, holes 54 perform both as a strainer for particulate matter contained in the water introduced to the fountain assembly and as flow regulators for predetermining the quantity of water discharged through grooves 60 relative to the quantity of water discharged through plug 31. Preferably the aggregate cross-sectional area of holes 54 is defined so that the major volume of the water introduced to chamber 46 is discharged from the nozzle assembly through plug 31. In this manner, the principal water stream through the nozzle assembly is axially through body tube 53 so that any solid matter contained within the water introduced to chamber 46 is induced to flow through plug 31 rather than through strainer and flow regulating holes 54 into chamber 59.

As set forth more fully in copending U.S. Pat. No. 3,705,686, it is desired that the water which enters the lower end of nozzle assembly 42 from base chamber 46 have a uniform liquid flow pattern at the water inlet opening to the nozzle assembly, and also that the flow characteristic (either turbulent or laminar) of the water entering the nozzle assembly be known. These characteristics of the water entering the lower end of body tube 53 at the inlet opening to nozzle assembly 42 are assured by the incorporation of a flow controlling and equalizing baffle assembly 65 which is carried by and depends from the lower end of body tube 53 into chamber 46. The baffle assembly is comprised of a pair of plates 66 and 67 (see FIG. 7) which are disposed perpendicular to each other. Each plate has a neck portion 68 which has a width corresponding to the inner diameter of body tube 53 and which is disposed within the lower terminal portion of the body tube, as shown in FIG. 5. Each plate also includes a lower blade portion which is of greater width than the neck portion, but which is smaller in transverse extent than the diameter of chamber 46. The baffle assembly is configured so that its lower extent is spaced above chamber floor 47 in the fully assembled fountain assembly. Also, the baffle assembly is disposed so that the plane of one of the baffle plates, baffle plate 67 for example, is aligned with the axes of coaxially aligned connection nipples 48. Thus, one-half of the water volume entering chamber 46 through each connection nipple 48 is directed to the nozzle assembly via a corresponding quadrant of the baffle assembly. This disposition of the baffle assembly relative to the chamber inlet opening assures that the water flow path through each quadrant of the baffle assembly is essentially identical to the water flow path associated with each other quadrant, thereby to assure that water actually entering the lower end of the nozzle assembly has the desired flow characteristic and uniform liquid flow pattern.

Nozzles 10, 30 and 35 have been found to be exceptionally efficient water discharge devices. One nominal 4 inch nozzle, having the features of nozzle 10, includes a plug 5 inches long and 3 ½ inches in diameter to fit within a nominal 4 inch diameter polyvinyl chloride pipe. The single water flow passage through this plug is composed of a circular hole 1 inch in diameter and six contiguous flutes approximately three-fourth inch deep (at the upper end of the plug) by one-half inch wide. The flutes in this nozzle have about 3° positive taper angle, and the half-angle of the conical recess at the bottom of the plug is about 35°. When connected to a 4 inch diameter water supply duct, this nozzle discharges a water stream 9 feet high at the rate of 300 gallons per minute when the water pressure at the nozzle inlet opening is 7 psi. This nozzle discharges a water stream
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48 feet high at the rate of 700 gpm when supply water through a 6 inch duct is 25 psig adjacent the nozzle. The same nozzle discharges 400 gpm at 12 psig in a 22 foot high water stream when the nozzle is disposed at an angle of 25° relative to a vertical reference line. When 450 gallons per minute of water is supplied at 32 psig to the inclined nozzle through a 6 inch water supply line, the discharge stream reaches a height of 45 feet and falls back to earth (at the level of the nozzle inlet opening) 100 feet away from the nozzle. A nozzle with these discharge characteristics can be used to advantage as a firefighting nozzle, for example. Therefore, it is apparent that nozzles according to this invention have utility in many areas apart from fountains in which the fountain water contains substantial entrained solid matter.

Workers skilled in the art to which this invention pertains will readily appreciate that modifications and alterations of the specific structures described above may be made while still utilizing the basic teachings of this invention. The preceding description has been presented with reference to presently preferred embodiments of the invention, which embodiments are illustrative of the principles and properties of nozzles according to the invention. Accordingly, the foregoing description should not be considered as limiting the scope of the invention.

What is claimed is:

1. A water discharge nozzle comprising an elongate tubular body having an outlet opening across one end thereof and an inlet opening across the other end thereof, annular plug means disposed in the body adjacent the outlet opening in spaced relation to the inlet opening and engaged about its circumference in intimate engagement with the inner walls of the body, the plug means defining a single passage therethrough, the passage being composed of a substantially circular hole which extends from the apex of a substantially conical recess in the end of the plug means adjacent the inlet opening, the recess being concave to the inlet opening, and a plurality of flutes in the walls of the hole and extending with the hole from the recess to the end of the plug means adjacent the outlet opening, each flute having opposing wall surfaces disposed in non-diverging relation proceeding radially away from the hole axis, the nozzle being devoid of any structure in the passage and being devoid of any structure located adjacent the end of the plug means proximate to the body outlet opening sufficiently to be engaged by water emerging from the passage during operation of the nozzle.

2. A nozzle according to claim 1 wherein the recess and the hole are coaxially aligned with the body.

3. A nozzle according to claim 1 wherein the plug means is disposed wholly within the body.

4. A nozzle according to claim 1 wherein the flutes have respective axes disposed parallel to the hole axis.

5. A nozzle according to claim 1 wherein the flutes have respective axes which diverge from the hole axis proceeding away from the recess.

6. A nozzle according to claim 1 wherein the flutes have respective axes which converge toward the hole axis proceeding away from the recess.

7. A nozzle according to claim 1 wherein the flutes have respective axes each of which is disposed in a respective plane radially of the hole and in which the hole axis is also disposed.

8. A nozzle according to claim 1 wherein adjacent flutes around the circumference of the hole are contiguous at said circumference.

9. A nozzle according to claim 1 wherein each flute extends radially away from the hole for a distance which is at least equal to the average width of the flute between said opposing wall surfaces thereof.

10. A nozzle according to claim 9 wherein the average depth of each flute radially of the hole is at least substantially equal to the radius of the hole.

11. A nozzle according to claim 1 wherein the opposing wall surfaces of each flute are substantially parallel.

12. A nozzle according to claim 1 wherein the recess at the end of the plug means adjacent the inlet opening has a diameter substantially equal to the inner diameter of the body.

13. A nozzle according to claim 1 wherein the half-angle of the recess is in the range of from about 30° to 45°.

14. A water discharge nozzle comprising an elongate tubular body having an outlet opening across one end thereof and an inlet opening across the other end thereof, annular plug means disposed in the body adjacent the outlet opening in spaced relation to the inlet opening and engaged about its circumference in intimate engagement with the inner walls of the body, the plug means defining a single passage therethrough, the passage being composed of a substantially circular hole which extends from the apex of a substantially conical recess in the end of the plug means adjacent the inlet opening, the recess being concave to the inlet opening, a plurality of flutes in the walls of the hole and extending with the hole from the recess to the end of the plug means adjacent the outlet opening, each flute having opposing wall surfaces disposed in non-diverging relation proceeding radially away from the hole axis, a tubular member having an inner diameter substantially greater than the outer diameter of the body disposed concentrically about the body, annular closure members engaged at opposite ends of the tubular member between the tubular member and the exterior of the body to define an annular chamber within the tubular member about the body, water outlet passage means formed through the closure member located adjacent the body outlet opening and arranged to discharge water from the chamber in a desired manner, and flow aperture means through the body to the chamber between the plug means and the body inlet opening.

15. A nozzle according to claim 14 wherein the passage means are arranged to discharge water from the chamber in a plurality of diverging water streams spaced uniformly circumferentially of the body.

16. A water discharge nozzle comprising an elongate tubular body having an outlet opening across one end thereof and an inlet opening across the other end thereof, annular plug means disposed in the body adjacent the outlet opening in spaced relation to the inlet opening and engaged about its circumference in intimate engagement with the inner walls of the body, the plug means defining a single passage therethrough, the passage being composed of a substantially circular hole which extends from the apex of a substantially conical recess in the end of the plug means adjacent the inlet opening, the recess being concave to the inlet opening, a plurality of flutes in the walls of the hole and extending with the hole from the recess to the end of the plug means disposed wholly within the body.
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means adjacent the outlet opening, each flute having opposing wall surfaces disposed in non-diverging relation proceeding radially away from the hole axis, a support base defining an internal chamber having coaxially aligned inlet openings thereto through side walls of the chamber, an outlet opening from an upper portion of the chamber, and means associated with the chamber outlet opening for mounting the nozzle to the base with the nozzle inlet opening in communication with the base chamber.

17. Apparatus according to claim 16 including flow controlling means in the chamber for causing water flowing along a path from the chamber inlet openings to the nozzle inlet opening to have a uniform liquid flow pattern at the nozzle inlet opening.

18. Apparatus according to claim 17 wherein the flow controlling means comprises a pair of perpendicular plates intersecting each other coaxially of the nozzle body and disposed in the chamber, one of the plates being aligned with the axes of the chamber inlet openings.

19. Apparatus according to claim 16 including means connected to the base and adapted for buoyantly supporting the base in a body of water.
CERTIFICATE OF CORRECTION

Patent No. 3,785,560 Dated January 15, 1974

Inventor(s) John O. Hruby, Jr.

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

Col. 4, line 47, "Te" should be --The--
Col. 6, line 62, after the word "about" insert --a--
Col. 8, line 19, after the words "30°" insert --about--
Col. 8, line 41, "eterior" should be --exterior--

Signed and sealed this 11th day of June 1974.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR. C. MARSHALL DANN
Attesting Officer Commissioner of Patents