A fire protection nozzle includes a body having two frame arms having proximal ends connected to an outlet of the body, and distal ends, the two frame arms defining a frame arm plane, and a junction formed by the distal ends of the frame arms, the junction including a central bore and a cylindrical outer wall. A circular deflector is mounted to the body, and includes a planar disk having a mounting hole in a center of the planar disk to receive the cylindrical outer wall of the junction, and a plurality of slots on a periphery of the circular planar disk. The plurality of slots includes four radial first slots, four radial second slots, eight radial third slots, and eight fourth slots. The nozzle has a K-factor of at least 28 gpm/(psi)^{1/2}. 

FIG. 1

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Title

FIRE PROTECTION NOZZLE, FIRE PROTECTION SPRINKLER, FIRE PROTECTION SYSTEMS, AND METHODS OF MANUFACTURING A FIRE PROTECTION NOZZLE AND A FIRE PROTECTION SPRINKLER

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 62/395,409, filed on September 16, 2016.

BACKGROUND OF THE INVENTION

[0002] This disclosure relates generally to a fire protection nozzle, a fire protection sprinkler, systems comprising a fire protection nozzle, systems comprising a fire protection sprinkler, and methods of manufacture.

[0003] Storage facilities that store goods, such as warehouses, require fire protection systems designed to minimize damage and to prevent loss of the stored goods in the event of a fire. A fire protection system for use in a storage facility may include one or more pendent fire protection sprinklers connected to a fire extinguishing fluid supply via a fluid supply conduit (i.e., piping). A fire protection system is activated when a thermally
responsive element, such as a glass bulb or a soldered link, fails, releasing a seal and opening an output orifice of the fire protection sprinkler. When the output orifice is opened, the fire extinguishing fluid, such as water, flows through the piping and the fire protection sprinkler and strikes a deflector mounted to the fire protection sprinkler. The deflector may be a circular planar disk having a number of slots arranged along the periphery of the disk, thereby producing a circular spray pattern of the fire extinguishing fluid. To meet the requirements for supply of fire extinguishing fluid over a given area to be protected, the particular arrangement of the slots on the deflector may be changed. Available fire protection systems meet the requirements for storage facilities having ceiling heights of up to thirty-five feet (10.67 meters). These systems, however, are not adequate for protection of storage facilities having heights up to forty feet (12.19 meters) or more.

[0004] In addition to the ceiling height of a storage facility, these fire protection systems are also designed based on the type of hazard (i.e., the commodity) stored in the storage facility. As an example, a fire protection system may be designed to protect an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by the National Fire Protection Association Standard 13 ("NFPA 13"), and as defined in the Property Loss Prevention Data Sheets 8-1 and 8-9, published by Factory Mutual (FM) Global Insurance of Johnston, Rhode Island.

[0005] Fire protection systems are also required in tunnels, such as those serving highway or railroad systems, to limit the destruction of fires involving passenger road vehicles, cargo trucks, or railroad cars. These systems must also be designed for exposure to freezing temperatures, since tunnels do not typically include heating systems. Fire protection systems designed for use in tunnels include nozzles that are connected to a fluid supply via a fluid supply conduit (i.e., piping). The fire protection system may activate using an
automatic detection unit or a manual activation unit. A deflector is mounted to each nozzle so that, when the fluid is supplied to the nozzle, the fluid strikes the deflector. The deflector may be a circular planar disk having a number of slots arranged on a periphery of the disk, thereby producing a circular spray pattern. In the fire protection sprinklers described, the circular spray pattern of adjacent sprinklers and nozzles may overlap, reducing the efficiency of the fire protection sprinkler system. In addition, the spacing provided between adjacent sprinklers and nozzles in these systems may be relatively small to ensure that the fire protection system meets the requirements for protection of a given area to be protected.

**SUMMARY OF THE INVENTION**

[0006] An object of our invention is to provide a fire protection system, including a nozzle, for use in tunnels for highways or railroads. The nozzle produces a spray pattern that improves the efficiency of the nozzle in delivering the fluid to the area to be protected. Another object of our invention is to provide a fire protection system in which nozzles may be provided at an increased spacing of up to 20 feet (6.096 meters) from each other, reducing the number of nozzles required by the system and, therefore, reducing the overall cost of the system.

[0007] It is another object of our invention to provide a fire protection sprinkler for protection of an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of greater than thirty five feet.
Yet another object of our invention is to provide a fire protection sprinkler that produces a rectangular spray pattern, improving the efficiency of the fire protection sprinkler in delivering the fluid to the area to be protected.

Still another object of our invention is to provide a fire protection sprinkler system in which adjacent fire protection sprinklers may be provided at an increased spacing of up to 14 feet (4.27 meters) from each other, reducing the number of sprinklers required by the system and, therefore, reducing the overall cost of the system.

In one embodiment of the present invention, a fire protection nozzle for providing fire protection in a tunnel comprises a body comprising an inlet orifice, an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction, two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane, and a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall. The nozzle further comprises a circular deflector configured to be mounted to the body of the nozzle. The circular deflector comprises a planar disk having a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction, and a plurality of slots on a periphery of the circular planar disk that define a plurality of tines. The plurality of slots includes four radial first slots each having a first slot axis that is at an angle of about 45° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth. Four radial second slots are also provided on the circular planar disk, each having a second slot axis that is at an angle of about 0° or 90° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent second slot, each of the second slots having a second slot depth that
is less than the first slot depth. Eight radial third slots are provided, each being adjacent to a
second slot, and each having a third slot axis that is less than about 45° relative to the
second slot axis of the adjacent second slot. Each third slot has a third slot depth that is less
than the second slot depth. In addition, eight fourth slots are provided, each being adjacent
to a first slot, and each having a first slot portion having a radial axis, and a second slot
portion, extending outward from the first slot portion relative to a center of the planar disk,
the second slot portion having a non-radial axis, and a width that increases from an inner
end of the second slot portion toward an outer, peripheral end of the second slot portion.
Each fourth slot has a fourth slot depth that is less than the first slot depth. The nozzle has a
K-factor of at least 28 gpm/(psi)^{1/2}.

[0011] In another embodiment, the circular deflector is secured to the junction by rolling
the cylindrical outer wall of the junction over an edge of the mounting hole on a surface of
the circular deflector opposite to a surface that faces the output orifice. In yet another
embodiment, the central bore of the junction has a threaded surface, and the circular
deflector is secured to the junction by a securing portion that includes a securing screw
having a head and a threaded portion that contacts the threaded surface of the central bore of
the junction, and a retaining nut that is mounted to the head of the securing screw.

[0012] In yet another embodiment, a fire protection nozzle further comprises comprising at
least two body deflectors that extend from each of the two frame arms in the frame arm
plane at an angle relative to the body axis, each of the at least two body deflectors having an
inner planar surface that faces the junction, the inner planar surface having a depth in the
frame arm plane and a width, perpendicular to the depth, wherein the body deflectors extend
in the frame arm plane at an angle of about 10° to about 80° from the body axis. In another
embodiment, the width of the inner planar surface of the body deflectors is about 0.3 to
about 1.2 times the diameter of the circular deflector. In yet another embodiment, the body deflectors extend in the frame arm plane at an angle of about 45° from the body axis.

[0013] In still another embodiment, a fire protection system for providing fire protection in a tunnel comprises a fluid supply for supply of a fluid, piping connected to the fluid supply, and a plurality of fire protection nozzles, each nozzle being connected to the piping. Each nozzle comprises a body comprising an inlet orifice, an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction, two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane, and a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall. Each nozzle further comprises a circular deflector configured to be mounted to the body of the nozzle. The circular deflector comprises a planar disk having a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction, and a plurality of slots on a periphery of the circular planar disk that define a plurality of tines. The plurality of slots includes four radial first slots each having a first slot axis that is at an angle of about 45° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth. Four radial second slots are also provided, each having a second slot axis that is at an angle of about 0° or about 90° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent second slot, each of the second slots having a second slot depth that is less than the first slot depth. Eight radial third slots are provided, each being adjacent to a second slot, and each having a third slot axis that is less than about 45° relative to the second slot axis of an adjacent second slot, the third slots having a third slot depth that is less than the second slot depth. Eight fourth
slots are provided, each being adjacent to a first slot, and each having a first slot portion having a radial axis, and a second slot portion, extending outward from the first slot portion relative to a center of the planar disk, the second slot portion having a non-radial axis, and a width that increases from an inner end of the second slot portion toward an outer, peripheral end of the second slot portion, and each of the fourth slots having a fourth slot depth that is less than the first slot depth. The fire protection system further comprises an actuation valve connected to the fluid supply, wherein, when the actuation valve is operated, the fluid supply supplies the fluid to the piping and the plurality of nozzles and the fluid is delivered by the nozzles to the area to be protected in a spray pattern. In addition, the nozzles are positioned at a spacing of up to 20 feet by 20 feet, and each nozzle has a K-factor of at least 28 gpm/(psi)$^{1/2}$.

[0014] In another embodiment, the body of each nozzle of the fire protection system has external threads on an outer surface near the inlet orifice, wherein the piping includes connection portions having threads on an inner surface, and wherein the external threads on the outer surface of the body of each nozzle contact the threads on the inner surface of the piping. In another embodiment, the circular deflector on each nozzle is secured to the junction of each nozzle by rolling the cylindrical outer wall of the junction over an edge of the mounting hole on a surface of the circular deflector opposite to a surface that faces the output orifice. In another embodiment, the central bore of the junction of each nozzle has a threaded surface, and the circular deflector is secured to the junction by a mounting portion that includes a securing screw having a head and a threaded portion that contact the threaded surface of the central bore of the junction a retaining nut that is mounted to the head of the securing screw.
In another embodiment, each nozzle of a fire protection system further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth. In this embodiment, the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector. In another embodiment, the body deflectors of each nozzle of the fire protection system extend in the frame arm plane at an angle of about 10° to about 80° from the body axis. In another embodiment, the body deflectors of each nozzle of the fire protection system extend in the frame arm plane at an angle of about 45° relative to the body axis.

In another embodiment, an extended coverage fire protection sprinkler for storage applications including protection of an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of greater than thirty five feet is provided. The sprinkler comprises a body comprising an inlet orifice, an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction, two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane, and a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore having threads on an inner surface, and a cylindrical outer wall. The sprinkler further comprises a circular deflector configured to be mounted to the body of the sprinkler, the circular deflector comprising a disk having a mounting hole in a center of the disk, the mounting hole configured to receive
the cylindrical outer wall of the junction, and a plurality of slots on a periphery of the disk that define a plurality of tines. The plurality of slots includes two radial first slots each having a first slot axis that is at an angle of about 90° relative to the plane defined by the frame arms, each of the first slots having a first slot depth. Four radial second slots are provided having a second slot axis that is at an angle of about 45° relative to the frame arm plane, each of the second slots having a second slot depth. Two third slots are provided, each having a third slot axis that coincides with the frame arm plane, the third slots having a third slot depth that is less than the first slot depth. Four fourth slots are provided, each being adjacent to third slot, and each having a fourth slot axis that is less than about 45° relative to the third slot axis of an adjacent third slot, the fourth slots having a fourth slot depth that is less than the third slot depth. Four fifth slots are provided, each being adjacent to one of the two first slots, and each fifth slot having a fifth slot axis that at an angle relative to the first slot axis of an adjacent first slot, and each of the fifth slots having a fifth slot depth that is less than the first slot depth. The sprinkler further comprises a securing portion configured to secure the circular deflector to the junction of the body. The securing portion includes a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction when the securing screw is inserted into the central bore, and a retaining nut that is mounted to the head of the securing screw. The sprinkler further comprises an actuation mechanism including a thermally responsive element supported by the threaded portion of the securing screw that extends through the central bore of the junction, the thermally responsive element being configured to fail when ambient temperature reaches a predetermined temperature, and an outlet seal that is supported by the thermally responsive element and that seals the outlet orifice until the thermally responsive element fails. The sprinkler has a K-factor of at least 28 gpm/(psi)\(^{1/2}\).
In another embodiment, each side of each of the third slots of the circular deflector of the sprinkler includes an inner point, and an outer point near the periphery of the circular disk, and each side of each of the fourth slots of the circular deflector includes an inner point, and an outer point near the periphery of the circular disk. In this embodiment, of the plurality of tines, a tine that is defined by a third slot and a fourth slot is bent about two axes defining a plane of the disk, so that the outer point on one side of the third slot is below a plane defined by the inner point on the one side of the third slot, the inner point on one side of the fourth slot, and the outer point on the one side of the fourth slot.

In yet another embodiment, the extended coverage fire protection sprinkler further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth. In this embodiment, the body deflectors extend in the frame arm plane at an angle of about 10° to about 80° from the body axis. In another embodiment, the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector. In another embodiment, the body deflectors extend in the frame arm plane at an angle of about 45° from the body axis.

In another embodiment, a fire protection system for storage applications including protection of an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of greater than thirty five feet is provided. The system comprises a fluid supply for supply of a fluid, piping connected to the fluid supply, and a plurality of fire protection sprinklers, each sprinkler
being connected to the piping. Each sprinkler comprises a body comprising an inlet orifice, an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction, two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane, and a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall. Each sprinkler further comprises a circular deflector configured to be mounted to the body of the sprinkler, the circular deflector comprising a planar disk having a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction, and a plurality of slots on a periphery of the circular planar disk that define a plurality of tines. The plurality of slots includes two radial first slots each having a first slot axis that is at an angle of about 90° relative to the plane defined by the frame arms, each of the first slots having a first slot depth. Four radial second slots are provided, having a second slot axis that is at an angle of about 45° relative to the frame arm plane, each of the second slots having a second slot depth. Two third slots are provided, each having a third slot axis that coincides with the frame arm plane, the third slots having a third slot depth that is less than the first slot depth. Four fourth slots are provided, each being adjacent to a third slot, and each having a fourth slot axis that is less than about 45° relative to the third slot axis of an adjacent third slot, the fourth slots having a fourth slot depth that is less than the third slot depth. Four fifth slots are provided, each being adjacent to one of the two first slots, and each fifth slot having a fifth slot axis that at an angle relative to the first slot axis of an adjacent first slot, and each of the fifth slots having a fifth slot depth that is less than the first slot depth. Each sprinkler further comprises an actuation mechanism including a thermally responsive element supported by the threaded portion of the securing screw that
extends through the central bore of the junction, the thermally responsive element being configured to fail when ambient temperature reaches a predetermined temperature, and an outlet seal that is supported by the thermally responsive element and that seals the outlet orifice until the thermally responsive element fails. When the thermally responsive element of at least one of the sprinklers fails, the fluid supply supplies the fluid to the at least one sprinkler through the piping, and the fluid is delivered by the at least one sprinkler to the area to be protected in a spray pattern. In addition, the sprinklers are positioned at a spacing of up to 14 feet by 14 feet, and the sprinkler has a K-factor of at least 28 gpm/(psi) \(1/2\).

[0020] In another embodiment, body of each sprinkler has external threads on an outer surface near the inlet orifice, and the piping includes connection portions having threads on an inner surface. In this embodiment, the external threads on the outer surface of the body of each sprinkler contact the threads on the inner surface of the piping. In another embodiment, the circular deflector on each sprinkler is secured to the junction of each sprinkler by rolling the cylindrical outer wall of the junction over an edge of the mounting hole on a surface of the circular deflector opposite to a surface that faces the output orifice.

[0021] In yet another embodiment, each side of each of the third slots of the circular deflector of each sprinkler includes an inner point, and an outer point near the periphery of the circular disk, and each side of each of the fourth slots of the circular deflector includes an inner point, and an outer point near the periphery of the circular disk. In this embodiment, of the plurality of tines, a tine that is defined by a third slot and a fourth slot is bent about two axes defining a plane of the disk, so that the outer point on one side of the third slot is below a plane defined by the inner point on the one side of the third slot, the inner point on one side of the fourth slot, and the outer point on the one side of the fourth slot.
[0022] In another embodiment, each sprinkler further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth. In this embodiment, the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector. In another embodiment, the body deflectors of each sprinkler extend in the frame arm plane at an angle of about 10° to about 80° from the body axis. In another embodiment, the body deflectors of each sprinkler extend in the frame arm plane at an angle of about 45° from the body axis.

[0023] In another embodiment, a method of manufacturing a fire protection nozzle for providing fire protection in a tunnel comprises providing a body, the body comprising an inlet orifice, an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction, two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane, and a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall. The method further comprises mounting a circular deflector to the body of the nozzle, the circular deflector comprising a planar disk having a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction, and a plurality of slots on a periphery of the circular planar disk. The plurality of slots includes four radial first slots each having a first slot axis that is at an angle of about 45° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth. Four radial second slots are provided,
each having a second slot axis that is at an angle of about 0° or 90° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent second slot, each of the second slots having a second slot depth that is less than the first slot depth. Eight radial third slots are provided, each being adjacent to a second slot, and each having a third slot axis that is less than about 45° relative to the second slot axis of the adjacent second slot, each of the third slots having a third slot depth that is less than the second slot depth. Eight fourth slots are provided, each being adjacent to a first slot, and each having a first slot portion having a radial axis, and a second slot portion, extending outward from the first slot portion relative to a center of the planar disk, the second slot portion having a non-radial axis, and a width that increases from an inner end of the second slot portion toward an outer, peripheral end of the second slot portion, and each of the fourth slots having a fourth slot depth that is less than the first slot depth. In addition, the nozzle has a K-factor of 28 gpm/(psi)^{1/2}.

[0024] In another embodiment, the method further comprises securing the circular deflector to the junction by rolling the cylindrical outer wall of the junction over an edge of the mounting hole on a surface of the circular deflector opposite to a surface that faces the output orifice. In another embodiment, the central bore of the junction has a threaded surface, and the method further comprises securing the circular deflector to the junction by a securing portion that includes a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction, and a retaining nut that is mounted to the head of the securing screw.

[0025] In yet another embodiment, the nozzle provided in the method further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the
frame arm plane and a width, perpendicular to the depth. In this embodiment, the body deflectors extend in the frame arm plane at an angle of about 10° to about 80° from the body axis. In another embodiment, the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector. In another embodiment, the body deflectors extend in the frame arm plane at an angle of about 45° from the body axis.

[0026] In another embodiment, a method of manufacturing an extended coverage fire protection sprinkler for storage applications including protection of an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of greater than thirty five feet, comprises providing a body having an inlet orifice, an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction, two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane, and a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore having threads on an inner surface, and a cylindrical outer wall. The method further comprises mounting a circular deflector to the body of the sprinkler. The circular deflector comprises a disk having a mounting hole in a center of the disk, the mounting hole configured to receive the cylindrical outer wall of the junction, and a plurality of slots on a periphery of the disk. The plurality of slots includes two radial first slots each having a first slot axis that is at an angle of about 90° relative to the plane defined by the frame arms, each of the first slots having a first slot depth. Four radial second slots are provided, having a second slot axis that is at an angle of about 45° relative to the frame arm plane, each of the second slots having a second
slot depth. Two third slots are provided, each having a third slot axis that coincides with the frame arm plane, the third slots having a third slot depth that is less than the first slot depth. Four fourth slots are provided, each being adjacent to a third slot, and each having a fourth slot axis that is less than about 45° relative to the third slot axis of an adjacent third slot, the fourth slots having a fourth slot depth that is less than the third slot depth. Four fifth slots are provided, each being adjacent to one of the two first slots, and each fifth slot having a fifth slot axis that is at an angle relative to the first slot axis of an adjacent first slot, and each of the fifth slots having a fifth slot depth that is less than the first slot depth. The method further comprises securing the circular deflector to the junction of the body using a securing portion that includes a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction when the securing screw is inserted into the central bore, and a retaining nut that is mounted to the head of the securing screw. The method further comprises providing an actuation mechanism including a thermally responsive element supported by the threaded portion of the securing screw that extends through the central bore of the junction, the thermally responsive element being configured to fail when ambient temperature reaches a predetermined temperature, and an outlet seal that is supported by the thermally responsive element and that seals the outlet orifice until the thermally responsive element fails. In addition, the sprinkler has a K-factor of 28 gpm/(psi)\(^{1/2}\).

[0027] In another embodiment, each side of each of the third slots of the circular deflector of the sprinkler, provided as a part of the method, includes an inner point, and an outer point near the periphery of the circular disk, and each side of each of the fourth slots of the circular deflector includes an inner point, and an outer point near the periphery of the circular disk. In this embodiment, of the plurality of tines, a tine that is defined by a third
slot and a fourth slot is bent about two axes defining a plane of the disk, so that the outer point on one side of the third slot is below a plane defined by the inner point on the one side of the third slot, the inner point on one side of the fourth slot, and the outer point on the one side of the fourth slot.

[0028] In another embodiment, the body of the sprinkler, provided as a part of the method, further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth. The body deflectors extend in the frame arm plane at an angle of about 10° to about 80° from the body axis. In another embodiment, the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector. In another embodiment, the body deflectors extend in the frame arm plane at an angle of about 45° from the body axis.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] Examples of certain embodiments of a fire protection nozzle and a fire protection sprinkler, according to the present invention, are illustrated in the accompanying figures, which form a part of this disclosure.

[0030] Figure 1 is an isometric view of a fire protection nozzle according to a preferred embodiment of the invention.

[0031] Figure 2 is a bottom view of the fire protection nozzle according to a preferred embodiment of the invention.
[0032] Figure 3 is a side view of a fire protection sprinkler according to a preferred embodiment of the invention.

[0033] Figure 4 is a side view of the fire protection sprinkler according to a preferred embodiment of the invention.

[0034] Figure 5 is an isometric view of the fire protection sprinkler according to a preferred embodiment of the invention.

[0035] Figure 6 is a plan view of a deflector for a fire protection sprinklers in a preferred embodiment of the invention.

[0036] Figure 7 is a side view of the deflector for a fire protection sprinkler in a preferred embodiment of the invention.

[0037] Figure 8 is a side view of the deflector for a fire protection sprinkler in a preferred embodiment of the invention.

[0038] Figure 9 is a sectional view of the deflector for a fire protection sprinkler in a preferred embodiment of the invention.

[0039] Figure 10 is a detail view of the deflector for a fire protection sprinkler in a preferred embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

[0040] In a preferred embodiment, a fire protection nozzle 100, as shown in Figures 1 and 2, may be used in a fire protection system for a tunnel that serves a highway or a railroad. The fire protection system includes a fluid supply that supplies a fluid, such as water, a network of piping connected to the fluid supply, and a plurality of fire protection nozzles 100 connected at various positions to the network of piping. In these systems, the nozzles 100 are actuated centrally, such that, in a case in which fire valves controlling the pipes are
operated (e.g., automatically or manually) in response to a fire, fluid is supplied to some or all of the nozzles 100, and is delivered by the nozzles 100 to control or to suppress the fire. In this application, temperature-sensitive actuation elements are not required in the nozzles 100. In addition, because the supply of the fluid to the nozzles 100 is controlled centrally within the fire protection system, the nozzles 100 do not require closure seals.

[0041] As shown, the nozzle 100 has a body 105 with an inlet orifice 110 and an outlet orifice 115 defining a flow passage 120 for the fluid along an axis of the body 105. The nozzle 100 connects to the piping network of the fire protection system using external threads 125 that are provided on an outer surface of the body 105 at an inlet end of the nozzle 100.

[0042] The body 105 has two frame arms 130 that extend from the outlet end of the nozzle 100 in a downward direction (i.e., in the general direction of flow of the fluid, or an output direction). The two frame arms 130 meet at a junction 135 that is a distance from the outlet orifice 115. The junction 135 has a central bore 140 that extends through the junction 135 in the output direction, and a cylindrical wall portion 145 on a lower end of the junction 135. An inner surface of the junction 135 may be threaded. A first deflector 160 is mounted to the body 105 at the junction 135 by, for example, positioning a mounting hole 165 of the deflector 150 over the junction 135, and rolling the cylindrical wall portion 145 of the junction 135 over the surface of the first deflector 160 defining the mounting hole 165. That is, when the first deflector 160 is mounted on the junction 135, the cylindrical wall portion 145 extends through the mounting hole 165 of the first deflector 160, so that rolling of that cylindrical wall portion 145 over the surface of the first deflector 160 serves to secure the first deflector 160 to the body 105 of the nozzle 100. Alternatively, the first deflector 160 may be mounted to the junction 135 using a securing screw 150 that is
inserted through the mounting hole 165 of the first deflector 160 and is threaded into the central bore 140 of the junction 135, and may be secured to the body 105 using a retaining nut 155. In one embodiment, second deflectors 205 may also be provided, each second deflector 205 being mounted on a respective one of the frame arms 130. When the fluid is supplied to the nozzle 100, the fluid enters the inlet orifice 110 of the body 105, exits through the outlet orifice 115 of the body 105, and impacts the junction 135 and the first deflector 160. The first deflector 160 directs the fluid downward and outward in a spray pattern, in order to quickly and efficiently control a fire.

[0043] As shown in Figure 2, the first deflector 160 is a circular planar disk 160a having the mounting hole 165 in the center for mounting the first deflector 160 to the junction 135 of the nozzle 100. The first deflector 160 includes a plurality of slots 170, 175, 180, 185 of varying depths and shapes, that define a plurality of tines 190, 195, and 200 of the first deflector 160. In particular, four first slots 170 are provided at equally-spaced positions on the first deflector 160, and each extends along a first slot axis that is at an angle, for example, of about 45°, relative to a plane defined by the frame arms 130 of the nozzle 100. Each of the first slots 170 is a straight slot that extends radially on the planar disk (i.e., the first slot axis coincides with a radius of the circular planar disk 160a), and has a constant width. In addition, each of the first slots 170 has a depth a, measured from the outer periphery toward the center of the circular planar disk 160a.

[0044] Four second slots 175 are provided at equally-spaced positions on the circular planar disk 160a, each second slot 175 being equally-spaced between two first slots 170. That is, each second slot 175 has a second slot axis that is at an angle, for example, of about 45°, relative to the first slot axis of two first slots 170. Two diametrically opposing slots of the second slots 175 A have axes that coincide with the plane defined by the frame arms 130.
of the nozzle 100. Each of the second slots 175 is a straight slot having a radial axis (i.e.,
the second slot axis coincides with a radius of the circular planar disk 160a), and has a
constant width. The second slots 175 have a slot depth b that is shorter than the slot depth a
of the first slots 170.

[0045] Eight third slots 180 are provided on the circular planar disk 160a. Each of the
second slots 175 is adjacent to two of the third slots 180, as shown in Figure 2. Each of the
third slots 180 is a straight slot having a radial axis (i.e., a third slot axis coincides with a
radius of the circular planar disk 160a), and has a constant width. The third slots 180 have a
slot depth c that is less than the slot depth b of the second slots 175.

[0046] Eight fourth slots 185 are provided on the circular planar disk 160a. Each of the
first slots 160 is adjacent to two of the fourth slots 185, as shown in Figure 2. In addition,
each of the fourth slots 185 is also adjacent to a third slot 180. Each fourth slot 185 has a
first portion 185a, having a constant width and a radial axis (i.e., a first portion axis
coincides with a radius of the circular planar disk 160a). In addition, each fourth slot 185
has a second portion 185b, having a varying width, with an inner end of the second portion
185b being narrower than an outer end of the second portion 185b, the outer end being the
end near the periphery of the circular planar disk 160a. In addition, an axis of the second
portion 185b of the fourth slot 185 does not coincide with a radius of the circular planar disk
160a. That is, the fourth slots 175 are non-radial, at least in part, relative to the circular
planar disk 160a.

[0047] First tines 190 of the first deflector 160 are defined by a first slot 170 and an
adjacent fourth slot 185. Second tines 195 are defined by a second slot 175 and an adjacent
third slot 180. Third tines 200 are defined by a third slot 180 and an adjacent fourth slot
185. In this embodiment, as shown in Figure 2, the first deflector 160 has eight first tines
190, eight second tines 195, and eight third tines 200. Of course, additional or fewer slots and tines may be provided on the deflector 160, depending on the application or design criteria.

[0048] When the first deflector 160 is mounted to the junction 135 of the nozzle 100, and the fluid is supplied from the fluid supply to the piping network, and through the outlet orifice 115 of the nozzle 100, some of the fluid flows downward through the slots 170, 175, 180, and 185, and some of the fluid is redirected by the tines 190, 195, and 200 of the first deflector in outward and upward directions. By this arrangement, the fluid can be sprayed in a generally circular spray pattern to an area below the nozzle 100.

[0049] In addition, in the embodiment including the second deflectors 205, the nozzle 100 can further shape the spray pattern of the fluid to direct the fluid toward a fire below the nozzle 100. That is, at least some of the fluid that is redirected by the tines 190, 195, and 200 of the first deflector 160 strikes the second deflectors 205. The second deflector 205 is shaped and positioned so as to intercept some or all of this fluid, and to redirect the fluid at least partly in the downward direction toward the fire. Additionally, the second deflectors 205 aid in shaping the spray pattern provided by the first deflector 160 of the nozzle 100. That is, as noted herein, the first deflector 160 may tend to produce a generally circular spray pattern, and, by redirecting some of the fluid that strikes the tines 190, 195, and 200 of the first deflector 160, the second deflectors 205 cause the spray pattern to have a more oblong, and preferably, a generally rectangular, shape.

[0050] The second deflectors 205 are diametrically opposed to each other relative to a center of the first deflector 160. In addition, the second deflectors 205 are provided in the plane defined by the frame arms 130, and are provided integrally with the frame arms 130 on the body 105 of the nozzle 100. Alternatively, the second deflectors 205 may be welded
to the frame arms 130. As shown in Figure 1, the second deflectors 205 are joined to the frame arms 130 at positions between the outlet orifice 115 of the body 105 and the junction 135. Each of the second deflectors 205 extends from the respective frame arm 130 at an angle, for example, of about 10° to about 80°, and more preferably, of about 30° to about 60°, and, even more preferably, of about 45° relative to the axis of the body 105 of the nozzle 100. That is, as shown in Figure 1, each of the second deflectors 205 extends from the respective frame arm 130 in a downward and outward direction relative to the axis of the body 105 of the nozzle 100.

[0051] Each of the second deflectors 205 has an inner planar surface 210, and has a depth (i.e., a distance from the edge of the second deflector 205 joined to the frame arm 130 to a free edge) of 1 inch (25.4 mm), and a width (i.e., a distance between edges of the planar surface 210 of the second deflector 205 that is perpendicular to the depth) of 0.95 inch (24.13 mm). The depth and width of each of the second deflectors 205 are not limited to these values. Indeed, in another embodiment, the depth of each of the second deflectors 205 may be sufficient to intersect the plane of the circular planar disk 160a of the first deflector 160. The width of each of the second deflectors 205 may be defined relative to a diameter of the first deflector 160. For example, the width of each of the second deflectors 205 may be about 0.3 to about 1.2 times the diameter of the first deflector 160.

[0052] Some of the fluid that strikes the tines 190, 195, and 200 of the first deflector 160, and that is redirected in an upward and outward direction relative to the axis of the body 105 of the nozzle 100, impacts the inner planar surface 210 of each of the second deflectors 205. The fluid that strikes the inner planar surfaces 210 of the second deflectors 205 is thus redirected downward and/or outward from the nozzle 100, in an oblong and, preferably, a generally rectangular spray pattern. By virtue of the relative dimensions and angle of the
second deflectors 205 relative to the first deflector 160 and to the axis of the body 105 of the nozzle 100, the efficiency of the nozzle 100 can be improved. That is, using the first deflector 160 and the second deflectors 205, the spray pattern of the fluid can be shaped to be approximately rectangular, thereby reducing overlap between spray patterns of adjacent nozzles.

[0053] A fire protection nozzle may be characterized by size according to a K-factor defined by $K = \frac{Q}{\sqrt{p}}$, where $Q$ is the flow rate in gallons per minute from the outlet of the nozzle, and $p$ is the residual pressure at the inlet of the sprinkler in pounds per square inch. According to one embodiment, the nozzle 100 has a nominal K-factor of approximately 28.0 gpm/(psi)$^{1/2}$, and may provide coverage for a tunnel with the nozzles 100 provided at a spacing of 20 x 20 feet (6.10 x 6.10 meters). The nozzle 100 may have a K-factor of up to 33.6 gpm/(psi)$^{1/2}$. While particular K-factor values are listed, higher and lower values are also within the scope of the invention (i.e., the K-factor may be a value of 15 to 60 gpm/(psi)$^{1/2}$ and, more particularly, from 25 to 45 gpm/(psi)$^{1/2}$).

[0054] In another embodiment, the first deflector 160 may include a different pattern of slots. In addition, the tines 190, 195, and 200 of the first deflector 160 between slots may be torsioned (i.e., twisted) relative to the plane of the circular planar disk 160a. This particular type of deflector is more suitable for use in a fire protection sprinkler, rather than a nozzle. It is, however, within the scope of the invention to use either of the deflector shapes disclosed herein in a fire protection sprinkler or a fire protection nozzle.

[0055] In a preferred embodiment, a fire protection sprinkler 300 may be used in a fire protection system for a storage facility having a ceiling height of forty feet (12.19 meters) or more. The fire protection system includes a fluid supply that supplies a fluid, such as water, a network of piping connected to the fluid supply, and a plurality of fire protection system elements.
sprinklers 300 connected at various positions to the network of piping. In these systems, the sprinklers 300 are individually activated by a thermally responsive element, such as a fusible link 385, as a part of an actuation mechanism 365.

[0056] As shown in Figures 3 to 5, the fire protection sprinkler 300 has a body 305 with an inlet orifice 310 and an outlet orifice 315, the inlet orifice 310 and the outlet orifice 315 defining a flow passage 320 along an axis of the body 305, and defining an output direction from the inlet orifice 310 toward the outlet orifice 315. The sprinkler 300 connects to the piping network of the first protection system using external threads 325 provided on an outer surface of the body 305 at an inlet end of the sprinkler 300.

[0057] The body 305 has two frame arms 330 that extend from the inlet end of the sprinkler 300 to the outlet end (i.e., in the general direction of flow of the fluid). The two frame arms 330 meet at a junction 335 having an upper surface at a distance from the outlet orifice 315, and a lower surface, opposite to the upper surface in the output direction. The junction 335 may have a central bore 340 with threads on an inner surface of the central bore 340. The junction 335 may also have a cylindrical wall portion 345 that extends in the outlet direction. A first deflector 370, including a circular disk 375, is mounted to the body 305 at the junction 335 by, for example, positioning a mounting hole 380 of the first deflector 370 over the junction 335, and rolling the edges of the cylindrical wall portion 345 of the junction 335 over the surface of the first deflector 370 defining the mounting hole 380. That is, when the first deflector 370 is mounted on the junction 335, the cylindrical wall portion 345 of the junction 335 extends through the mounting hole 380 of the first deflector 370, so that rolling of that cylindrical wall portion 345 of the junction 235 over the surface of the first deflector 370 serves to secure the first deflector 370 to the body 305 of the sprinkler 300. Alternatively, the first deflector 37 may be mounted to the junction 335 using
a securing screw 350 that is inserted through the mounting hole 380 of the first deflector 370 and is threaded into the central bore 340 of the junction 335, and may be secured to the body 305 using a retaining nut 355.

[0058] As noted, the actuation mechanism 365 is used to actuate the sprinkler 300. The actuation mechanism 365 maintains a sealed state of an outlet seal assembly 360 in the outlet orifice 315 of the sprinkler 300. As shown in Figures 3 and 5, the actuation mechanism 365 may include the fusible link 385 as a thermally responsive element that is supported by the securing screw 350 when the retaining nut 355 is inserted into the central bore 340 of the junction 335. In response to ambient temperature reaching a predetermined temperature, the fusible link 385 fails, releasing the actuation mechanism 365 and, therefore, releasing the outlet seal assembly 360 from the outlet orifice 315. Upon release of the outlet seal assembly 360, the fluid is permitted to flow through the flow passage 320 of the sprinkler 300. After the fluid exits through the outlet orifice 315, some of the fluid strikes the first deflector 370 mounted to the junction 335 and is redirected in an outward and/or an upward direction relative to an axis of the body 305 of the sprinkler 300.

[0059] In this embodiment, second deflectors 345 are also provided, each second deflector 435 being mounted on a respective one of the frame arms 330. When the fluid is supplied to the sprinkler 300, the fluid enters the inlet orifice 310 of the body 305, exits through the outlet orifice 315 of the body 305, and impacts the junction 335 and the first deflector 370. The first deflector 370 directs the fluid downward and outward in a spray pattern, in order to quickly and efficiently control a fire.

[0060] The first deflector 370 will be described with reference to Figures 6 to 10. The first deflector 370 is a circular, mostly planar disk 375 having a mounting hole 380 in a center for mounting the first deflector 370 to the junction 335 of the sprinkler 300. The first
deflector 370 includes a plurality of slots 390, 395, 400, 405, and 410 of varying depths and shapes, that define a plurality of tines 415, 420, 425, 430 of the first deflector 370. In particular, as shown in Figure 6, two first slots 390 are provided at positions so as to extend along a first slot axis that is at an angle, for example, about 90° relative to the plane defined by the frame arms 330 of the sprinkler 300. Each of the first slots 390 is a straight slot that extends radially on the circular disk 375 (i.e., the first slot axis coincides with a radius of the circular disk 375) and has a constant width m. In addition, each of the first slots 390 has a depth a, measured from the outer periphery toward the center of the circular disk 375.

[0061] Four second slots 395 are provided at positions so as to extend along a second slot axis that is at an angle, for example, of about 45° relative to the plane defined by the frame arms 330 of the sprinkler 300. Each of the second slots 395 is a straight slot that extends radially on the circular disk 375 (i.e., the second slot axis coincides with a radius of the circular disk 375) and has a constant width m. In addition, each of the second slots 395 has the same depth a as the first slots 390.

[0062] Two third slots 400 are provided at diametrically opposing positions on the circular disk 375, and each third slot 400 extends along a third slot axis that coincides with the plane defined by the frame arms 330 of the sprinkler 300. Each of the third slots 400 is a straight slot having a radial axis (i.e., the second slot axis coincides with a radius of the circular disk), and has a constant width n. The third slots 400 have a slot depth b that is shorter than the slot depth a of the first and second slots 390, 395. In addition, as shown in the detail view of Figure 10, each third slot 400 has an inner point 400a, on an inner surface, that demarcates the beginning of a torsioned tine 430 (described below) of the first deflector 370, and an outer point 400b on the inner surface that coincides with the outer periphery of
the circular disk 375 and demarcates the end of the torsioned tine 430 of the first deflector 370.

[0063] Four fourth slots 405 are provided on the circular disk 375. Each of the two third slots 400 is adjacent to a third slot 405, as shown in Figure 6. Each of the third slots 405 has a non-radial axis (i.e., the third slot axis does not coincide with a radius of the circular disk), the non-radial axis being at an angle α relative to a radius of the circular disk 375, as shown in Figure 6. The angle α may be about 15°. The fourth slots 405 have a constant width and a slot depth c that is less than the slot depth b of the third slots 400. In addition, each of the fourth slots 405 has an inner point 405a, on an inner surface, that demarcates the beginning of the torsioned tine 430 of the first deflector 370, and an outer point 400b on the inner surface that coincides with the outer periphery of the circular disk 375 and demarcates the end of the torsioned tine 430 of the first deflector 370.

[0064] Four fifth slots 410 are provided on the circular disk 375. Each of the first slots 390 is adjacent to two fifth slots 410, as shown in Figure 6. Each of the fifth slots 410 has a constant width and a non-radial axis (i.e., the fifth slot axis does not coincide with a radius of the first deflector 370). The non-radial axis of each of the fifth slots 410 is at an angle β relative to a radius of the circular disk 375. In the embodiment shown in Figure 6, the angle β is between 0° and 90°.

[0065] The first to fifth slots 390, 395, 400, 405, and 410 have radiused ends (i.e., at an inner extremity, the end of each slot is radiused), as shown in Figure 6. In addition, first tines 415 of the first deflector 370 are defined by a first slot 390 and an adjacent fifth slot 410. Second tines 420 are defined by a second slot 395 and an adjacent fifth slot 410. Third tines 425 are defined by a second slot 395 and an adjacent fourth slot 405. Fourth tines 430 are defined by a third slot 400 and a fourth slot 405. In this embodiment, as
shown in Figure 6, the first deflector 370 has four first tines 415, four second tines 420, four third tines 425, and four fourth tines 430. Of course, additional slots and tines may be provided on the deflector 370.

[0066] Each of fourth tines 430 between the third slot 400 and the fourth slot 405 are torsioned (i.e., bent in multiple planes). As shown in Figures 7 to 9, the fourth tine 430 is bent about at least two axes in three-dimensional space (in Figures 7 to 9, the fourth tine 430 is bent about an x-axis and a y-axis). The bending of the fourth tine 430 is also illustrated by the relative positions of the inner point of the third slot 400a, the outer point of the third slot 400b, the inner point of the fourth slot 400a, and the outer point of the fourth slot 400b. The inner point of the third slot 400a lies in the plane of the circular disk 375, and demarcates a point of the fourth tine 430 at which the fourth tine 430 is bent about a horizontal axis so that the outer point of the third slot 400b is below the plane of the circular disk 375 (i.e., the fourth tine 430 is bent about the x-axis, as shown in Figures 7 to 9). In addition, the inner point of the fourth slot 405a lies in the plane of the circular disk 375, and demarcates a point of the fourth tine 430 at which the fourth tine 430 is bent. The outer point of the fourth slot 405b is positioned within the plane of the circular disk 375 as with the inner point of the fourth slot 400a. The outer point of the third slot 400b is positioned lower than the inner point of the third slot 400a along a vertical axis (i.e., the z-axis in Figures 7 to 9), representing the bending of the fourth tine 430 about the y-axis. In addition, the outer point of the third slot 400b is positioned lower than the outer point of the fourth slot 405b along the vertical axis (z-axis), representing bending of the fourth tine 430 about a normal axis (i.e., the z-axis in Figures 7-9). The bending of the fourth tine 430 between the third slot 400 and the fourth slot 405 about multiple axes generates a curvilinear, torsioned
surface on the fourth tine 430, as shown at least in Figures 7 to 9, and as shown schematically in Figure 10.

[0067] When the first deflector 370 is mounted to the junction 335 of the sprinkler 300, and the fluid is supplied from the fluid supply to the piping network, and through the outlet orifice 315 of the sprinkler 300, some of the fluid flows downward through the slots 390, 395, 400, 405, and 410, and some of the fluid is redirected by the tines 415, 420, 425, and 430 of the first deflector 370 in outward and upward directions. By this arrangement, the fluid can be sprayed in a generally circular spray pattern to an area below the sprinkler 300.

[0068] In addition, the second deflectors 435 also serve to direct the fluid toward a fire below the sprinkler 300. That is, at least some of the fluid that strikes the tines 415, 420, 425, and 430 of the first deflector 370 and is redirected in outward and upward directions strikes the second deflectors 435. The second deflectors 435 are shaped and positioned so as to intercept some or all of this fluid, and to redirect the fluid at least partly in the downward direction toward the fire. Additionally, the second deflectors 435 aid in shaping the spray pattern provided by the first deflector 370 of the sprinkler 300. That is, as noted herein, the first deflector 370 may tend to produce a generally circular spray pattern, and, by redirecting some of the fluid that strikes the tines 415, 420, 425, 430 of the first deflector 370, the second deflectors 435 cause the spray pattern to have a more oblong, and preferably, a generally rectangular, shape.

[0069] The second deflectors 435 are diametrically opposed to each other relative to a center of the first deflector 370. In addition, the second deflectors 435 are provided in the plane defined by the frame arms 330, and are provided integrally with the frame arms 330 on the body 305 of the sprinkler 300. Alternatively, the second deflectors 435 may be welded to the frame arms 330. As shown in Figure 3, the second deflectors 435 are joined
to the frame arms 330 at positions between the outlet orifice 315 of the body 305 and the junction 335. Each of the second deflectors 435 extends from the respective frame arm 330 at an angle, for example, of about 10° to about 80°, and more preferably, of about 30° to about 60°, and, even more preferably, of about 45° relative to the axis of the body 305 of the sprinkler 300. That is, as shown in Figure 3, each of the second deflectors 435 extends from the respective frame arm 330 in a downward and outward direction relative to the axis of the body 305 of the sprinkler 300.

Each of the second deflectors 435 has an inner planar surface, and has a depth (i.e., a distance from the edge of the second deflector 435 joined to the frame arm 330 to a free edge) of 1 inch (25.4 mm), and a width (i.e., a distance between edges of the planar surface of the second deflector 435 that is perpendicular to the depth) of 0.95 inch (24.13 mm). The depth and width of each of the second deflectors 435 are not limited to these values. Indeed, in another embodiment, the depth of each of the second deflectors 435 may be sufficient to intersect the plane of the circular disk of the first deflector 370. The width of each of the second deflectors 435 may be defined relative to a diameter of the first deflector 370. For example, the width of each of the second deflectors 435 may be about 0.3 to about 1.2 times the diameter of the first deflector 370.

Some of the fluid that strikes the tines 415, 420, 425, and 430 of the first deflector 370, and that is redirected in an upward and outward direction relative to the axis of the body 305 of the sprinkler 300, impacts an inner planar surface 440 of each of the second deflectors 435. The fluid that strikes the inner planar surface 440 of the second deflectors 435 is thus redirected downward and/or outward from the sprinkler 300, in an oblong and, preferably, a generally rectangular spray pattern. By virtue of the relative dimensions and angle of the second deflectors 435 relative to the first deflector 370 and the axis of the body
305 of the sprinkler 300, the efficiency of the sprinkler 300 can be improved. That is, using the first deflector 370 and the second deflectors 435, it is possible to refine the spray pattern of the fluid to be almost "squared off," allowing avoidance of overlap between spray patterns of adjacent nozzles.

[0072] Further, the curvilinear, torsioned surface of the fourth tine 430 between the third slots 400 and the fourth slots 405 of the first deflector 370 creates a path of least resistance for fluid that strikes the first deflector 370 after exiting the outlet orifice 315 of the sprinkler 300. As a result, when the fluid is output by the sprinkler 300, a jet of fluid forms through the third slots 400 and the fourth slots 405, in a direction corresponding to the plane defined by the frame arms 330. The jet of fluid then strikes the second deflectors 435, and is directed in a squared off, or rectangular spray pattern. In a fire protection sprinkler system including sprinklers 300 having the above-described first deflector 370 that generates a jet of fluid by virtue of the torsioned fourth tine 430, and second deflectors 435 that create a rectangular spray pattern, it is possible to increase the spacing between sprinklers 300, thereby minimizing overlap between sprinklers 300.

[0073] In another embodiment, the first deflector may have at least one, and preferably four, apertures extending through the thickness of the deflector disk. These apertures may be located symmetrically around the center of the disk, and may be generally curvilinear in form, e.g., oval.

[0074] The sprinkler of this embodiment is designed for use in a sprinkler system for protection of an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of greater than 35 feet (10.67 meters).
As noted above with respect to a fire protection nozzle, a fire protection sprinkler may be characterized by size according to a K-factor defined by \( K = \frac{Q}{\sqrt{P}} \), where \( Q \) is the flow rate in gallons per minute from the outlet of the sprinkler, and \( P \) is the residual pressure at the inlet of the sprinkler in pounds per square inch. According to one embodiment, the sprinkler 300 has a nominal K-factor of \( 28 \text{ gpm/(psi)}^{1/2} \) up to \( 33.6 \text{ gpm/(psi)}^{1/2} \). While particular K-factor values are listed, higher and lower values are also within the scope of the invention (i.e., the K-factor may be a value of \( 15 \) to \( 60 \text{ gpm/(psi)}^{1/2} \) and, more particularly, from \( 25 \) to \( 45 \text{ gpm/(psi)}^{1/2} \).

The sprinkler 300 having a nominal K-factor of \( 28 \text{ gpm/(psi)}^{1/2} \) up to \( 33.6 \text{ gpm/(psi)}^{1/2} \) may provide coverage for a storage occupancy with a ceiling height of 40 feet (12.19 meters), with the sprinklers provided at a spacing of over 10 x 10 feet (3.05 x 3.05 meters), and in particular, at a spacing of 12 x 12 feet (3.66 x 3.66 meters), or of 14 x 14 feet (4.27 x 4.27 meters). In addition, the sprinklers 300 are extended coverage sprinklers, as defined in NFPA 13 section 3.6.4.3, having a maximum coverage area of up to 196 square feet (18.21 square meters) for an extra hazard occupancy, as provided in NFPA 13 sections 8.8 and 8.9.

The descriptions of the embodiments herein are not limiting. For example, it is within the broad scope of the invention to vary the number of each type of slot or tine, as well as the exact dimensions of each type of slot or tine. Further, features of the first deflector, as described in the embodiments herein, may be combined. In addition, the second deflector need not be mounted directly on the frame arms, but may be supported directly by the nozzle or sprinkler body. Of course, other systems of support may be adopted as found to be convenient. Although the second deflector is shown as having two symmetric portions, the second deflector may instead be formed as a single element.
extending from one side of the apparatus to the other, or largely or entirely encircling the apparatus (i.e., the nozzle or the sprinkler), and neither the second deflector nor portions of the second deflector need to be generally planar as shown, but may be curved if preferred. [0078] While the present invention has been described with respect to what are, at present, considered to be the preferred embodiments, it is to be understood that the invention is not limited to the disclosed embodiments. To the contrary, the invention is intended to cover various modifications and equivalent arrangements included within the spirit and scope of the appended claims.
I CLAIM:

1. A fire protection nozzle for providing fire protection in a tunnel, the nozzle comprising:
   (A) a body comprising:
      (a) an inlet orifice;
      (b) an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction;
      (c) two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane; and
      (d) a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall; and
   (B) a circular deflector configured to be mounted to the body of the nozzle, the circular deflector comprising a planar disk having:
      (a) a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction; and
      (b) a plurality of slots on a periphery of the circular planar disk that define a plurality of tines, the plurality of slots including:
         (i) four radial first slots each having a first slot axis that is at an angle of about 45° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth;
         (ii) four radial second slots each having a second slot axis that is at an angle of about 0° or 90° relative to the frame arm plane, and at an angle of
about 90° relative to an adjacent second slot, each of the second slots having a second slot depth that is less than the first slot depth;

(iii) eight radial third slots each being adjacent to a second slot, and each having a third slot axis that is less than about 45° relative to the second slot axis of the adjacent second slot, each of the third slots having a third slot depth that is less than the second slot depth; and

(iv) eight fourth slots each being adjacent to a first slot, and each having a first slot portion having a radial axis, and a second slot portion, extending outward from the first slot portion relative to a center of the planar disk, the second slot portion having a non-radial axis, and a width that increases from an inner end of the second slot portion toward an outer, peripheral end of the second slot portion, and each of the fourth slots having a fourth slot depth that is less than the first slot depth,

wherein the nozzle has a K-factor of at least 28 gpm/(psi)\(^{1/2}\).
(i) a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction; and

(ii) a retaining nut that is mounted to the head of the securing screw.

4. A fire protection nozzle according to claim 1, further comprising at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth, wherein the body deflectors extend in the frame arm plane at an angle of about 10° to about 80° from the body axis.

5. A fire protection nozzle according to claim 4, wherein the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector.

6. A fire protection nozzle according to claim 4, wherein the body deflectors extend in the frame arm plane at an angle of about 45° from the body axis.

7. A fire protection system for providing fire protection in a tunnel, the system comprising:

   (A) a fluid supply for supply of a fluid;

   (B) piping connected to the fluid supply;

   (C) a plurality of fire protection nozzles, each nozzle being connected to the piping, and each nozzle comprising:
(a) a body comprising:

(i) an inlet orifice;

(ii) an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction;

(iii) two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane; and

(iv) a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall; and

(b) a circular deflector configured to be mounted to the body of the nozzle, the circular deflector comprising a planar disk having:

(i) a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction; and

(ii) a plurality of slots on a periphery of the circular planar disk that define a plurality of tines, the plurality of slots including:

    (1) four radial first slots each having a first slot axis that is at an angle of about 45° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth;

    (2) four radial second slots each having a second slot axis that is at an angle of about 0° or about 90° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent second slot, each of
the second slots having a second slot depth that is less than the first slot depth;

(3) eight radial third slots each being adjacent to a second slot, and each having a third slot axis that is less than about 45° relative to the second slot axis of an adjacent second slot, the third slots having a third slot depth that is less than the second slot depth; and

(4) eight fourth slots each being adjacent to a first slot, and each having a first slot portion having a radial axis, and a second slot portion, extending outward from the first slot portion relative to a center of the planar disk, the second slot portion having a non-radial axis, and a width that increases from an inner end of the second slot portion toward an outer, peripheral end of the second slot portion, and each of the fourth slots having a fourth slot depth that is less than the first slot depth; and

(D) an actuation valve connected to the fluid supply, wherein, when the actuation valve is operated, the fluid supply supplies the fluid to the piping and the plurality of nozzles and the fluid is delivered by the nozzles to the area to be protected in a spray pattern, wherein the nozzles are positioned at a spacing of up to 20 feet by 20 feet, and each nozzle has a K-factor of at least 28 gpm/(psi)^{1/2}.

8. A fire protection system according to claim 7, wherein (i) the body of each nozzle has external threads on an outer surface near the inlet orifice, (ii) the piping includes connection portions having threads on an inner surface, and (iii) the external threads on the outer surface of the body of each nozzle contact the threads on the inner surface of the piping.
9. A fire protection system according to claim 7, wherein the circular deflector on each nozzle is secured to the junction of each nozzle by rolling the cylindrical outer wall of the junction over an edge of the mounting hole on a surface of the circular deflector opposite to a surface that faces the output orifice.

10. A fire protection system according to claim 7, wherein the central bore of the junction of each nozzle has a threaded surface, and wherein the circular deflector is secured to the junction by a mounting portion that includes:

   (i) a securing screw having a head and a threaded portion that contact the threaded surface of the central bore of the junction; and

   (ii) a retaining nut that is mounted to the head of the securing screw.

11. A fire protection system according to claim 7, wherein each nozzle further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth,

   wherein the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector.

12. A fire protection system according to claim 11, wherein the body deflectors of each nozzle extend in the frame arm plane at an angle of about 10° to about 80° from the body axis.
13. A fire protection system according to claim 11, wherein the body deflectors of each nozzle extend in the frame arm plane at an angle of about 45° relative to the body axis.

14. An extended coverage fire protection sprinkler for storage applications including protection of an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of greater than thirty five feet, the sprinkler comprising:

   (A) a body comprising:

      (a) an inlet orifice;

      (b) an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction;

      (c) two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane; and

      (d) a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore having threads on an inner surface, and a cylindrical outer wall; and

   (B) a circular deflector configured to be mounted to the body of the sprinkler, the circular deflector comprising a disk having:

      (a) a mounting hole in a center of the disk, the mounting hole configured to receive the cylindrical outer wall of the junction; and

      (b) a plurality of slots on a periphery of the disk that define a plurality of tines, the plurality of slots including:
(i) two radial first slots each having a first slot axis that is at an angle of about 90° relative to the plane defined by the frame arms, each of the first slots having a first slot depth;

(ii) four radial second slots having a second slot axis that is at an angle of about 45° relative to the frame arm plane, each of the second slots having a second slot depth;

(iii) two third slots each having a third slot axis that coincides with the frame arm plane, the third slots having a third slot depth that is less than the first slot depth;

(iv) four fourth slots each being adjacent to a third slot, and each having a fourth slot axis that is less than about 45° relative to the third slot axis of an adjacent third slot, the fourth slots having a fourth slot depth that is less than the third slot depth; and

(v) four fifth slots each being adjacent to one of the two first slots, and each fifth slot having a fifth slot axis that is at an angle relative to the first slot axis of an adjacent first slot, and each of the fifth slots having a fifth slot depth that is less than the first slot depth;

(C) a securing portion configured to secure the circular deflector to the junction of the body, the securing portion including:

(a) a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction when the securing screw is inserted into the central bore; and

(b) a retaining nut that is mounted to the head of the securing screw; and

(D) an actuation mechanism including:
(a) a thermally responsive element supported by the threaded portion of the securing screw that extends through the central bore of the junction, the thermally responsive element being configured to fail when ambient temperature reaches a predetermined temperature; and

(b) an outlet seal that is supported by the thermally responsive element and that seals the outlet orifice until the thermally responsive element fails,

wherein the sprinkler has a K-factor of at least 28 gpm/(psi)$^{1/2}$.

15. An extended coverage fire protection sprinkler according to claim 14, wherein each side of each of the third slots of the circular deflector includes:

   (i) an inner point; and
   (ii) an outer point near the periphery of the circular disk,

wherein each side of each of the fourth slots of the circular deflector includes:

   (i) an inner point; and
   (ii) an outer point near the periphery of the circular disk, and

wherein, of the plurality of tines, a tine that is defined by a third slot and a fourth slot is bent about two axes defining a plane of the disk, so that the outer point on one side of the third slot is below a plane defined by the inner point on the one side of the third slot, the inner point on one side of the fourth slot, and the outer point on the one side of the fourth slot.

16. An extended coverage fire protection sprinkler according to claim 14, further comprising at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors
having an inner planar surface that faces the junction, the inner planar surface having a depth
in the frame arm plane and a width, perpendicular to the depth,

wherein the body deflectors extend in the frame arm plane at an angle of about 10° to
about 80° from the body axis.

17. An extended coverage fire protection sprinkler according to claim 16, wherein the
width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the
diameter of the circular deflector.

18. An extended coverage fire protection sprinkler according to claim 16, wherein the
body deflectors extend in the frame arm plane at an angle of about 45° from the body axis.

19. A fire protection system for storage applications including protection of an
occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as
defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9,
stored in a storage area having a ceiling height of greater than thirty five feet, the system
comprising:

(A) a fluid supply for supply of a fluid;

(B) piping connected to the fluid supply;

(C) a plurality of fire protection sprinklers, each sprinkler being connected to the
piping, and each sprinkler comprising:

(a) a body comprising:

(i) an inlet orifice;
(ii) an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction;

(iii) two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane; and

(iv) a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall;

(b) a circular deflector configured to be mounted to the body of the sprinkler, the circular deflector comprising a planar disk having:

(i) a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction; and

(ii) a plurality of slots on a periphery of the circular planar disk that define a plurality of tines, the plurality of slots including:

(1) two radial first slots each having a first slot axis that is at an angle of about 90° relative to the plane defined by the frame arms, each of the first slots having a first slot depth;

(2) four radial second slots having a second slot axis that is at an angle of about 45° relative to the frame arm plane, each of the second slots having a second slot depth;

(3) two third slots each having a third slot axis that coincides with the frame arm plane, the third slots having a third slot depth that is less than the first slot depth;
(4) four fourth slots each being adjacent to a third slot, and each having a fourth slot axis that is less than about 45° relative to the third slot axis of an adjacent third slot, the fourth slots having a fourth slot depth that is less than the third slot depth; and

(5) four fifth slots each being adjacent to one of the two first slots, and each fifth slot having a fifth slot axis that is at an angle relative to the first slot axis of an adjacent first slot, and each of the fifth slots having a fifth slot depth that is less than the first slot depth; and

(c) an actuation mechanism including:

   (i) a thermally responsive element supported by the threaded portion of the securing screw that extends through the central bore of the junction, the thermally responsive element being configured to fail when ambient temperature reaches a predetermined temperature; and

   (ii) an outlet seal that is supported by the thermally responsive element and that seals the outlet orifice until the thermally responsive element fails, wherein, when the thermally responsive element of at least one of the sprinklers fails, the fluid supply supplies the fluid to the at least one sprinkler through the piping, and the fluid is delivered by the at least one sprinkler to the area to be protected in a spray pattern, and

   wherein the sprinklers are positioned at a spacing of up to 14 feet by 14 feet, and the sprinkler has a K-factor of at least 28 gpm/(psi)$^{1/2}$. 
20. A fire protection system according to claim 19, wherein (i) the body of each sprinkler has external threads on an outer surface near the inlet orifice, (ii) the piping includes connection portions having threads on an inner surface, and (iii) the external threads on the outer surface of the body of each sprinkler contact the threads on the inner surface of the piping.

21. A fire protection system according to claim 19, wherein the circular deflector on each sprinkler is secured to the junction of each sprinkler by rolling the cylindrical outer wall of the junction over an edge of the mounting hole on a surface of the circular deflector opposite to a surface that faces the output orifice.

22. A fire protection system according to claim 19, wherein each side of each of the third slots of the circular deflector of each sprinkler includes:

   (i) an inner point; and

   (ii) an outer point near the periphery of the circular disk,

   wherein each side of each of the fourth slots of the circular deflector includes:

   (i) an inner point; and

   (ii) an outer point near the periphery of the circular disk, and

   wherein, of the plurality of tines, a tine that is defined by a third slot and a fourth slot is bent about two axes defining a plane of the disk, so that the outer point on one side of the third slot is below a plane defined by the inner point on the one side of the third slot, the inner point on one side of the fourth slot, and the outer point on the one side of the fourth slot.
23. A fire protection system according to claim 19, wherein each sprinkler further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth, and wherein the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector.

24. A fire protection system according to claim 23, wherein the body deflectors of each sprinkler extend in the frame arm plane at an angle of about 10° to about 80° from the body axis.

25. A fire protection system according to claim 23, wherein the body deflectors of each sprinkler extend in the frame arm plane at an angle of about 45° from the body axis.

26. A method of manufacturing a fire protection nozzle for providing fire protection in a tunnel, the method comprising:

(A) providing a body having:

(a) an inlet orifice;

an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction;

(c) two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane; and
(c) a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall; and

(B) mounting a circular deflector to the body of the nozzle, the circular deflector comprising a planar disk having:

(a) a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction; and

(b) a plurality of slots on a periphery of the circular planar disk, the plurality of slots including:

(i) four radial first slots each having a first slot axis that is at an angle of about 45° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth;

(ii) four radial second slots each having a second slot axis that is at an angle of about 0° or 90° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent second slot, each of the second slots having a second slot depth that is less than the first slot depth;

(iii) eight radial third slots each being adjacent to a second slot, and each having a third slot axis that is less than about 45° relative to the second slot axis of the adjacent second slot, each of the third slots having a third slot depth that is less than the second slot depth; and

(iv) eight fourth slots each being adjacent to a first slot, and each having a first slot portion having a radial axis, and a second slot portion, extending outward from the first slot portion relative to a center of the planar disk, the second slot portion having a non-radial axis, and a width that
increases from an inner end of the second slot portion toward an outer, peripheral end of the second slot portion, and each of the fourth slots having a fourth slot depth that is less than the first slot depth, wherein the nozzle has a K-factor of 28 gpm/(psi)\(^{1/2}\).

27. A method of manufacturing a fire protection nozzle according to claim 26, further comprising securing the circular deflector to the junction by rolling the cylindrical outer wall of the junction over an edge of the mounting hole on a surface of the circular deflector opposite to a surface that faces the output orifice.

28. A method of manufacturing a fire protection nozzle according to claim 26, wherein the central bore of the junction has a threaded surface, and the method further comprises:

(C) securing the circular deflector to the junction by a securing portion that includes:

(i) a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction; and

(ii) a retaining nut that is mounted to the head of the securing screw.

29. A method of manufacturing a fire protection nozzle according to claim 26, wherein the nozzle further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth, and
- 51 -

wherein the body deflectors extend in the frame arm plane at an angle of about 10° to
about 80° from the body axis.

30. A method of manufacturing a fire protection nozzle according to claim 29,
wherein the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2
times the diameter of the circular deflector.

31. A method of manufacturing a fire protection nozzle according to claim 29,
wherein the body deflectors extend in the frame arm plane at an angle of about 45° from the
body axis.

32. A method of manufacturing an extended coverage fire protection sprinkler for
storage applications including protection of an occupancy hazard including classes I-IV and
Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property
Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of
greater than thirty five feet, the method comprising:

(A) providing a body having:

(a) an inlet orifice;

(b) an outlet orifice, the inlet orifice and the outlet orifice defining a body axis
and a flow passage for a fluid that flows through the body in an output direction;

(c) two frame arms having proximal ends connected to the outlet and distal
ends, the two frame arms defining a frame arm plane; and
(d) a junction formed by the distal ends of the frame arms at a distance from
the outlet orifice, the junction including a central bore having threads on an inner
surface, and a cylindrical outer wall;

(B) mounting a circular deflector to the body of the sprinkler, the circular deflector
comprising a disk having:

(a) a mounting hole in a center of the disk, the mounting hole configured to
receive the cylindrical outer wall of the junction; and

(b) a plurality of slots on a periphery of the disk, the plurality of slots
including:

(i) two radial first slots each having a first slot axis that is at an angle
of about 90° relative to the plane defined by the frame arms, each of the first
slots having a first slot depth;

(ii) four radial second slots having a second slot axis that is at an angle
of about 45° relative to the frame arm plane, each of the second slots having a
second slot depth;

(iii) two third slots each having a third slot axis that coincides with the
frame arm plane, the third slots having a third slot depth that is less than the
first slot depth;

(iv) four fourth slots each being adjacent to a third slot, and each
having a fourth slot axis that is less than about 45° relative to the third slot axis
of an adjacent third slot, the fourth slots having a fourth slot depth that is less
than the third slot depth; and

(iv) four fifth slots each being adjacent to one of the two first slots, and
each fifth slot having a fifth slot axis that is at an angle relative to the first slot
axis of an adjacent first slot, and each of the fifth slots having a fifth slot depth that is less than the first slot depth;

(C) securing the circular deflector to the junction of the body using a securing portion including:

(a) a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction when the securing screw is inserted into the central bore; and

(b) a retaining nut that is mounted to the head of the securing screw; and

(D) providing an actuation mechanism including:

(a) a thermally responsive element supported by the threaded portion of the securing screw that extends through the central bore of the junction, the thermally responsive element being configured to fail when ambient temperature reaches a predetermined temperature; and

(b) an outlet seal that is supported by the thermally responsive element and that seals the outlet orifice until the thermally responsive element fails,

wherein the sprinkler has a K-factor of 28 gpm/(psi)\(^{1/2}\).

33. A method of manufacturing an extended coverage fire protection sprinkler according to claim 32, wherein each side of each of the third slots of the circular deflector includes:

(i) an inner point; and

(ii) an outer point near the periphery of the circular disk,

wherein each side of each of the fourth slots of the circular deflector includes:

(i) an inner point; and
(ii) an outer point near the periphery of the circular disk, and

wherein, of the plurality of tines, a tine that is defined by a third slot and a fourth slot is bent about two axes defining a plane of the disk, so that the outer point on one side of the third slot is below a plane defined by the inner point on the one side of the third slot, the inner point on one side of the fourth slot, and the outer point on the one side of the fourth slot.

34. A method of manufacturing an extended coverage fire protection sprinkler according to claim 32, wherein the body of the sprinkler further comprises at least two body deflectors that extend from each of the two frame arms in the frame arm plane at an angle relative to the body axis, each of the at least two body deflectors having an inner planar surface that faces the junction, the inner planar surface having a depth in the frame arm plane and a width, perpendicular to the depth, and

wherein the body deflectors extend in the frame arm plane at an angle of about 10° to about 80° from the body axis.

35. A method of manufacturing an extended coverage fire protection sprinkler according to claim 34, wherein the width of the inner planar surface of the body deflectors is about 0.3 to about 1.2 times the diameter of the circular deflector.

36. A method of manufacturing an extended coverage fire protection sprinkler according to claim 34, wherein the body deflectors extend in the frame arm plane at an angle of about 45° from the body axis.
INTERNATIONAL SEARCH REPORT

INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - A62C 31/02, A62C 35/00, A62C 37/11, B05B 1/26 (2017.01)


According to International Patent Classification (IPC) or to both national classification and IPC.

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History Document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History Document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History Document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<tbody>
<tr>
<td>A</td>
<td>US 8,172,001 B2 (Tow et al.) 8 May 2012 (08.05.2012) entire document, especially Title, Abstract, figs. 1-4, col 5, ln 1-50.</td>
<td>4-6, 11-25, 29-36</td>
</tr>
<tr>
<td>A</td>
<td>US 5,366,022 A (Meyer et al.) 22 November 1994 (22.11.1994) entire document.</td>
<td>4-6, 11-25, 29-36</td>
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</table>

Further documents are listed in the continuation of Box C.

D. FURTHER DOCUMENTS

* Special categories of cited documents:

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed
- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "Z" document member of the same patent family

Date of the actual completion of the international search

27 December 2017

Date of mailing of the international search report

17 JAN 2018

Name and mailing address of the ISA/US

Lee W. Young
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**INTERNATIONAL SEARCH REPORT**

**Box No. II  Observations where certain claims were found unsearchable**

(Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.: because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claims Nos.: because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claims Nos.: because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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**Box No. III  Observations where unity of invention is lacking**

(Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

This application contains the following inventions or groups of inventions which are not so linked as to form a single general inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I: Claims 1-13, drawn to a fire protection nozzle and a system comprising the same.

Group II: Claims 14-25, 32-36 drawn to an extended coverage fire protection system, having thermally responsive element and a method of manufacturing an extended coverage fire protection system.

Group III: Claims 26-31, drawn to a method manufacturing a fire protection system.

The inventions listed as Groups I-III do not relate to a single general inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons:

- See Extra Sheet-

1. □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. □ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.

3. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

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**Remark on Protest**

□ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

□ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

□ No protest accompanied the payment of additional search fees.
INTERNATIONAL SEARCH REPORT

<table>
<thead>
<tr>
<th>International application No.</th>
<th>PCT/US 17/51881</th>
</tr>
</thead>
</table>

-**Box III** - Observations where unity of invention is lacking-**-

SPECIAL TECHNICAL FEATURES

Group I has the special technical features of the system comprising:

- (A) a fluid supply for supply of a fluid;
- (B) piping connected to the fluid supply;
- (C) a plurality of fire protection nozzles, each nozzle being connected to the piping and each nozzle comprising,
  - (D) an actuation valve connected to the fluid supply, wherein, when the actuation valve is operated, the fluid supply supplies the fluid to the piping and the plurality of nozzles and the fluid is delivered by the nozzles to the area to be protected in a spray pattern, wherein the nozzles are positioned at a spacing of up to 20 feet by 20 feet, not required by Groups II-IV

Group II has the special technical features of a fire protection sprinkler for storage applications including protection of an occupancy hazard including classes I-IV and Group A cartoned, unexpanded plastics, as defined by NFPA 13 and FM Global Property Loss Prevention Data Sheets 8-1 and 8-9, stored in a storage area having a ceiling height of greater than thirty five feet, the sprinkler comprising:

- (C) a securing portion configured to secure the circular deflector to the junction of the body, the securing portion including:
  - (a) a securing screw having a head and a threaded portion that contacts the threaded surface of the central bore of the junction when the securing screw is inserted into the central bore; and
  - (b) a retaining nut that is mounted to the head of the securing screw; and
- (D) an actuation mechanism including:
  - (a) a thermally responsive element supported by the threaded portion of the securing screw that extends through the central bore of the junction, the thermally responsive element being configured to fail when ambient temperature reaches a predetermined temperature; and
  - (b) an outlet seal that is supported by the thermally responsive element and that seals the outlet orifice until the thermally responsive element fails

the plurality of slots including:

- (i) two radial first slots each having a first slot axis that is at an angle of about 90° relative to the plane defined by the frame arms, each of the first slots having a first slot depth;
- (ii) four radial second slots each having a second slot axis that is at an angle of about 45° relative to the frame arm plane, each of the second slots having a second slot depth;
- (iii) two third slots each having a third slot axis that coincides with the frame arm plane, the third slots having a third slot depth that is less than the first slot depth;
- (iv) four fourth slots each being adjacent to a third slot, and each having a fourth slot axis that is less than about 45° relative to the third slot axis of an adjacent third slot, the fourth slots having a fourth slot depth that is less than the third slot depth; and
- (v) five fifth slots each being adjacent to one of the two first slots, and each fifth slot having a fifth slot axis that is at an angle relative to the first slot axis of an adjacent first slot, and each of the fifth slots having a fifth slot depth that is less than the first slot depth, not required by Groups I, III.

Group III has the special technical feature of a method of manufacturing the fire protection nozzle of Group I.

Group III has the special technical features method of manufacturing a fire protection nozzle having (i) four radial first slots each having a first slot axis that is at an angle of about 90° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth;

- (iii) eight radial third slots each being adjacent to a second slot, and each having a third slot axis that is less than about 45° relative to the second slot axis of an adjacent second slot, each of the third slots having a third slot depth that is less than the second slot depth; and
- (iv) eight fourth slots each being adjacent to a first slot, and each having a first slot portion having a radial axis, and a second slot portion, extending outward from the first slot portion relative to a center of the planar disk, the second slot portion having a non-radial axis, and a width that increases from an inner end of the second slot portion toward an outer, peripheral end of the second slot portion, and each of the fourth slots having a fourth slot depth that is less than the first slot depth not required by Group II.

SHARED TECHNICAL FEATURES

The only technical features shared between Groups I and II is a fire protection system for providing fire protection, the nozzle comprising:

- (A) a body comprising;
  - (a) an inlet orifice;
  - (b) an outlet orifice, the inlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction;
  - (c) two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane; and
  - (d) a junction formed by the distal ends of the frame arms at a distance from the outlet orifice (118), the junction including a central bore and a cylindrical outer wall;
  - (B) a circular deflector configured to be mounted to the body of the nozzle, the circular deflector comprising a planar disk having:
    - (a) a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction; and
    - (b) a plurality of slots on a periphery of the circular planar disk that define a plurality of lines, the plurality of slots and wherein the nozzle has a K-factor of at least 28 gpm/(psi) \*0.5, which does not provide any contribution over the prior art as it is anticipated by US 2011/0035590 A1 in lieu of US 8,172,001 B2.

-Continued in next Supplemental Box-*
Groups I and III are related as an apparatus (Group I) and a method of manufacturing the apparatus (Group III). Groups I and II sharing the technical features of a fire protection nozzle providing fire protection in a tunnel, the method comprising:

(A) providing a body having:
- an inlet orifice;
- an outlet orifice and the outlet orifice defining a body axis and a flow passage for a fluid that flows through the body in an output direction;
- two frame arms having proximal ends connected to the outlet and distal ends, the two frame arms defining a frame arm plane; and
- a junction formed by the distal ends of the frame arms at a distance from the outlet orifice, the junction including a central bore and a cylindrical outer wall;

and

(B) mounting a circular deflector to the body of the nozzle, the circular deflector comprising a planar disk having:
- a mounting hole in a center of the planar disk, the mounting hole configured to receive the cylindrical outer wall of the junction; and
- a plurality of slots on a periphery of the circular planar disk, the plurality of slots including:
  (i) four radial first slots each having a first slot axis that is at an angle of about 45° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent first slot, each of the first slots having a first slot depth;
  (ii) four radial second slots each having a second slot axis that is at an angle of about 0° or 90° relative to the frame arm plane, and at an angle of about 90° relative to an adjacent second slot, each of the second slots having a second slot depth that is less than the first slot depth;
  (iii) eight radial third slots each being adjacent to a second slot, and each having a third slot axis that is less than about 45° relative to the second slot axis of the adjacent second slot, each of the third slots having a third slot depth that is less than the second slot depth; and
  (iv) eight fourth slots each having an axis of about 45° relative to the second slot axis and a width that increases from an inner end, peripheral end of the second slot portion, and each of the fourth slots having a fourth slot depth that is less than the first slot depth,

wherein the nozzle has a K-factor of 28 gpm/(psi)^0.5.

But the apparatus is known in the prior art as shown by Pahila in view of US 8,172,001 B2 to Tow et al. (hereinafter "Tow"). Therefore, Group I and Group II lack unity since the shared technical features are known in the prior art. (Pahila in view of Tow).

Pahila teaches a fire protection nozzle (Title; Abstract; fig.1) for providing fire protection in a tunnel (said nozzle capable of being used in a tunnel), the nozzle comprising:

(A) a body (105; fig.1; para[0034]) comprising:
- an inlet orifice (115; fig.1);
- an outlet orifice (119), the inlet orifice and the outlet orifice defining a body axis (said inlet 115 and outlet 118 defining a fluid passage axis; fig.2) and a flow passage for a fluid that flows through the body in an output direction (para[0034]; figs. 1-2);
- two frame arms (125; para[0035]) having proximal ends connected to the outlet (118) and distal ends, the two frame arms (125) defining a frame arm plane (see figs. 1-3; wherein arms 125 are co-planar and form an arm plane that is coaxial with generally horizontal axis line generally labeled 310, fig.3); and
- a junction (130) formed by the distal ends of the frame arms (125; figs. 1-2) at a distance from the outlet orifice (118), the junction including a central bore (see threaded central bore generally 210 fig.2) and a cylindrical outer wall (see protruding outer cylindrical wall not labeled but generally receiving deflector 140 at bottom end of junction 130; figs. 1-2); and

(B) a circular deflector (140; para[0035]; figs. 1-2) configured to be mounted to the body (105) of the nozzle, the circular deflector comprising a planar disk (figs. 1-3) having:
- a mounting hole (see center hole for mounting onto junction 130; figs. 1-3) in a center of the planar disk (140), the mounting hole configured to receive the cylindrical outer wall of the junction (see fig.2); and
- a plurality of slots (145; figs. 1-3; para[0035]) on a periphery of the circular planar disk (140) that define a plurality of times (145), the plurality of slots including:
  (i) four radial first slots (320) each having a first slot axis that is at an angle of about 45° relative to the arm frame plane (horizontal axis line generally labeled 310; fig.3), and at an angle of about 90° relative to an adjacent first slot (320), each of the first slots having a first slot depth (see slot depth of all slots 320; fig.3);
  (ii) four radial second slots (310) each having a second slot axis that is at an angle of about 0° or 90° relative to the arm frame plane (see slots 310 at 0 degrees and 90 degrees to horizontal plane line; fig. 3), and at an angle of about 90° relative to an adjacent second slot (310), each of the second slots having a second slot depth that is less than the first slot depth (see slots 310 having slot depth less than slot 320); and
  (iii) eight radial third slots (330) each having a third slot axis that is less than about 45° relative to the second slot axis of the adjacent second slot (see slots 330 initiating the slot depth at a point of less than 45 degrees from slots 310 on both side of slots 310), each of the third slots having a third slot depth that is less than the second slot depth (said slots 330 having a slot depth less than slot 310; fig. 3); and

wherein the nozzle has a K-factor of at least 28 gpm/(psi)^0.5 (see para[0023]).

Further, Tow teaches a fire protection nozzle assembly having a planar deflection disk (title; Abstract; figs. 1-4) wherein the deflector disk (19; fig.4) includes a plurality of slots (a, b, c; N; fig.4; col 5, ln 1-14) wherein a total of 24 slots may be present in the disk, the plurality of slots are disposed at varying angles around the disk in repeated fashion, specifically a set of asymmetrical slots b are disposed at eight positions around the circular disk (fig.3) each asymmetrical slot b is disposed on either side of a slot c which is disposed at 45 degrees from the horizontal (similar to slot 320-Pahila; fig.3), wherein the symmetrical slots having an enlarged outer portion (41; fig.3); col5. In 32-38) to provide a disruption to the water distribution pattern and may be used to direct water to a area.

-Continued in next Supplemental Box-
"-Box III - Observations where unity of invention is lacking.-

Therefore, it would have been obvious to a person having ordinary skill in the art to have used the asymmetrical deflector slots of Tow to modify the circular deflector of Pahila to include eight asymmetrical slots (b-Tow) adjacent to said first slots (320-Pahila) to provide an improved water distribution pattern that includes an interference or disruption in the spray pattern through the directing of a portion of the water to a specific location via the asymmetrical slots.

As the common features were known in the art at the time of the invention, they cannot be considered special technical features that would otherwise unify the groups.

Therefore, Groups I-III lack unity under PCT Rule 13 because they do not share a same or corresponding special technical feature.