



(51) International Patent Classification:

A62C 37/14 (2006.01) B05B 1/34 (2006.01)
A62C 31/05 (2006.01) B05B 1/14 (2006.01)
B05B 1/20 (2006.01)

(21) International Application Number:

PCT/US2017/040347

(22) International Filing Date:

30 June 2017 (30.06.2017)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

62/357,841 01 July 2016 (01.07.2016) US

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(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ,
CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN,
HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP,
KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME,
MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ,
OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA,
SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN,
TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(54) Title: A HIGH PRESSURE WATER MIST NOZZLE DEVICE AND METHODS FOR PROVIDING INDIRECT AND DIRECT
IMPINGEMENT OF A FIRE

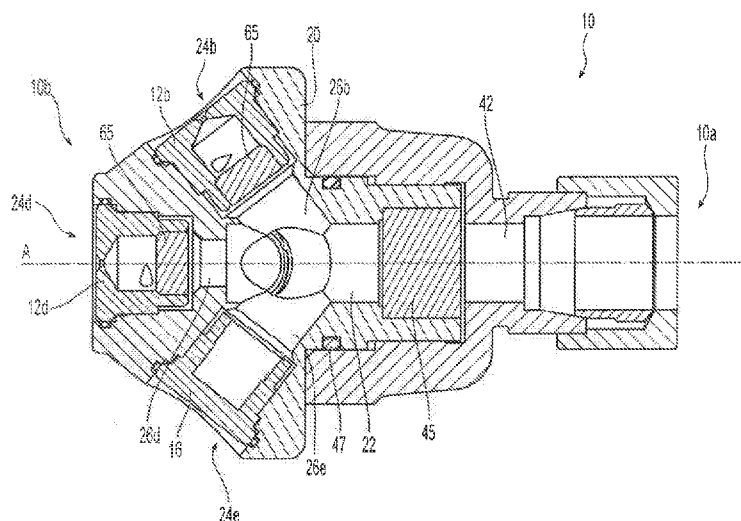


Fig. 3B

(57) Abstract: Water mist nozzles and methods of installation in which a water mist nozzle (10) has a main body with multiple orifice inserts (12b, 12d, 16) secured to the body that are configured differently to provide varying spray patterns and mist from a single device. The main body has a central bore (22) with a plurality of sockets (24b, 24d, 24e) formed about the central bore into which an orifice insert is secured. Each orifice insert (12b, 12d, 16) has at least one inlet, at least one outlet and an internal chamber. Among the plurality of orifice inserts is an orifice insert (12b, 12d) of a first type to generate a fluid mist for providing indirect impingement of a fire (total flooding) and an orifice insert (16) of a second type to generate a fluid mist or spray for providing direct impingement of a fire plume in the protection of an object or space.



(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

A HIGH PRESSURE WATER MIST NOZZLE DEVICE AND METHODS FOR PROVIDING INDIRECT AND DIRECT IMPINGEMENT OF A FIRE

Priority Claim & Incorporation By Reference

[0001] This international application claims the benefit of priority to U.S. Provisional Patent Application No. 62/357,841, filed July 1, 2016, which is incorporated by reference in its entirety.

Background of the Invention

[0002] Water mist nozzle heads used in known water mist systems provide fire protection for equipment and occupied areas such as, for example, ships, machine rooms and spaces, generator rooms, turbine rooms, data process centers, or underground public transport. These nozzle heads, a group of micro-nozzles or nozzle inserts are secured about a main nozzle body. Each nozzle insert of the nozzle head is configured to generate and discharge a mist or spray having a droplet size for providing total flooding for wetting or cooling to indirectly impinge or address a fire or other potential combustible source. In total flooding, high pressure water is discharged as a mist in which tiny drops create a large effective cooling surface area of the fire and surrounding volume.

[0003] Each of the nozzle inserts of known water mist nozzle heads has an internal chamber with multiple inlets positioned to introduce water into the chamber and generate a swirling effect. The water is discharged from the chamber through a single central outlet of the nozzle in the form of a mist having a droplet size to provide the total flooding effect. The inventors have discovered that total flooding has been ineffective in providing fire protection for certain equipment and occupied areas. For example, the inventors have determined that total flooding

nozzles are believed to be ineffective in the protection of equipment in cable tunnels and other similarly situated equipment and occupied areas. It is believed that in the presence of a fire in certain equipment and/or occupied areas, the generated mist from total flooding nozzle heads are not sufficient to cool the surrounding environment or control the fire within desired limits. It is believed that a likely cause for the performance deficiency is that the droplets in the total flooding, homogenous mist lose their velocity shortly after leaving the nozzle heads. The low velocity droplets tend to get pushed away from the fire by the air currents. Thus for certain applications, it is believed that the total flooding mist does not actively or directly impinge the fire and instead only cools the upper gas layer above the fire.

Disclosure of the Invention

[0004] Preferred embodiments of a water mist nozzle device generate a mist that provides a mixture of droplet sizes for both indirect impingement mist protection (total flooding) and additionally direct impingement mist and/or spray protection to address a fire. The preferred devices include a main body with multiple orifice nozzles or orifice inserts secured to the body. Differently configured orifice inserts are used to provide the varying spray patterns and mist from a single device. In preferred embodiments of the device, one type of orifice insert discharges a mist that includes a droplet size that is larger the droplet size of a mist discharged from the another type of orifice insert of the device.

[0005] One preferred embodiment of a water mist nozzle includes a body having a central bore extending along a central longitudinal nozzle axis. The body includes a plurality of sockets formed about the central bore. Each socket includes a lateral bore extending between the socket and the central bore. The nozzle also includes a plurality of orifice inserts. Each orifice insert has at least one inlet, at least one outlet and an internal chamber disposed along a central insert

axis for fluid communication with the at least one inlet and the at least one outlet. Among the plurality of orifice inserts are indirect impingement orifice inserts and at least one direct impingement orifice insert. The preferred mist nozzle can be configured as normally open for immediate discharge upon system operation; or alternatively configured for automatic operation in which fluid discharge from the nozzle upon actuation of a thermally responsive trigger. Preferred embodiments of a direct impingement orifice insert include an inlet coaxially aligned with the insert axis and a plurality of outlets surrounding the insert axis. Preferably, each of the plurality of outlets extend obliquely with respect to the insert axis to define an included angle ranging from 20°-25°. Moreover, the plurality of outlets of the second type of orifice insert include four outlets.

[0006] Embodiments of the water mist nozzle device provide a preferred method of water mist nozzle protection that includes generating a first type of fluid mist from a first type of orifice insert disposed in one of a plurality of sockets formed in a nozzle body into which a firefighting fluid is introduced and generating a second type of fluid mist from a second type of orifice insert disposed in another one of the plurality of sockets. The second type of fluid mist preferably has a droplet size that is greater than the first type of fluid mist to directly impinge a fire, while the first type of fluid mist provides total flooding protection.

[0007] Another preferred method of water mist nozzle protection includes installing at least two water mist nozzles above a ground to protect an area or object where each nozzle has a plurality of orifice inserts about a nozzle axis with at least one orifice insert configured for generating a first mist to address a fire with indirect impingement and at least one orifice insert configured for generating a mist to address a fire with direct impingement. The at least one direct impingement orifice insert is preferably oriented to face the floor. The preferred method

includes orienting each nozzle so that the nozzle axes of the at least two nozzles define an included angle ranging from 5°-20° with respect to a horizontal parallel to ground with the included angles of the at least two nozzles being different from one another. The preferred methodologies are believed to be suitable for the protection of cable tunnels or similarly configured occupied areas.

Brief Descriptions of the Drawings

[0008] The accompanying drawings, which are incorporated herein and constitute part of this specification, illustrate exemplary embodiments of the invention, and, together with the general description given above and the detailed description given below, serve to explain the features of the invention.

[0009] FIG. 1 is a perspective view of a preferred water mist nozzle.

[0010] FIGS. 2A-2B are side and end views of the nozzle of FIG. 1 in a preferred installed position.

[0011] FIGS. 3A-3B are respective cross-sectional side views of the nozzle of FIG. 1 along lines IIIA--IIIA and IIIB--IIIB.

[0012] FIG. 4 is an alternate preferred embodiment of a water mist nozzle.

[0013] FIG. 5A is an end view of a preferred embodiment of an orifice insert for use in the water mist nozzles of FIGS. 1 & 4.

[0014] FIGS. 5B--5C are cross-sectional views of the orifice insert of FIG. 4A.

[0015] FIG. 6A is a side view of another orifice insert for use in the water mist nozzles of FIGS. 1 & 4.

[0016] FIGS. 6B-6C are cross-sectional views of the orifice insert of FIG. 6A.

[0017] FIG. 7 is a schematic view of a fluid distribution set up using the water mist nozzle of FIG. 1.

Detailed Description of the Preferred Embodiments

[0018] Shown in FIG. 1 is a perspective view of a preferred embodiment of a water mist nozzle 10 having a first end 10a and a second end 10b spaced apart along a central longitudinal nozzle axis A--A. The nozzle 10 is preferably an open water mist nozzle into which a firefighting fluid such as water, for example, can be introduced into the device 10 at the first inlet end 10a for immediate discharge from the second end 10b of the device 10. At the second end 10b of the device 10 are a number of orifice inserts 12, 16 for generating and discharging a fluid mist, spray or discharge for addressing a fire and/or wetting and cooling the surrounding environment. Among the orifice inserts of a preferred embodiment of the device 10 are indirect impingement orifice inserts for generating a mist for addressing a fire with a mist or total flooding and one or more direct impingement orifice inserts for generating a mist and/or spray with droplets sufficient in size and velocity to penetrate and directly address a fire.

[0019] With reference to FIGS. 2A and 2B, shown is the device 10 in a preferred installed orientation above a floor or ground G. As shown, a number of orifice inserts 12, 16 are angularly and preferably equiangularly spaced about the nozzle axis A--A, each being of a varying type configured to provide a fluid discharge of a particular fluid flow, pressure, volume, density and/or droplet size. For example, in preferred embodiments described herein, there are orifice inserts 12 of a first type to provide a fluid mist for total flooding with wetting and/or cooling of the surrounding environment for indirectly addressing a fire or hazard and orifice inserts 16 of a second type for providing direct fluid impingement to address a fire or protect an object or area. In the particular embodiment shown, there are three orifice inserts 12a, 12b, 12c

of the first type and one orifice insert 16 of the second type. The device 10 can include additional orifice inserts for discharging the firefighting fluid. In the device 10 shown, another orifice insert of the first type 12d is axially aligned with central axis A--A to provide a central orifice insert for discharging the firefighting fluid in line with the inlet of the first end 10a of the device 10. Alternatively or additionally, an orifice insert of the second type can be disposed along the central nozzle axis A--A to provide a direct impingement spray. As seen in FIG. 2B, the first type of orifice insert 12a, 12b, 12c, 12d each have a single outlet 14a, 14b, 14c, 14d and the second type of orifice insert 16 has multiple outlets 18 to effect the overall desired fluid discharge.

[0020] In a preferred installation orientation of the device 10, the direct impingement orifice insert 16 is located so that its discharge impinges or impacts the surface, object or other hazard being protected. For example in a preferred installation orientation shown in FIG. 2A, the insert 16 is angled downward with the nozzle axis A--A defining an included angle α with respect to a horizontal H extending parallel to the floor or ground G such that the direct impingement orifice insert 16 faces the floor or ground G (or an object positioned thereon) to provide the preferred direct impingement protection. Thus for preferred embodiments of the water mist nozzle device 10, the direct impingement orifice insert 16 defines a preferred installation orientation for a given application or installation environment or geometry. In one example of an installation for the preferred embodiment of the device 10, the included angle α can range from 5°-20° and more preferably ranges from 8° or 18°. More preferably, when two or more nozzle devices are installed above the ground G and spaced apart from one another to protect an object or area, at least two of the nozzles define different included angles α with respect to the ground G.

[0021] Shown in FIGS. 3A and 3B are cross-sectional views of the device 10. The assembled device 10 includes a nozzle body 20 having a central bore 22 extending along the central longitudinal nozzle axis A--A. The body 20 includes a plurality of sockets 24a, 24b, 24c, 24d, 24e for receipt of an orifice insert 12, 16. Each of the orifice inserts 12, 16 are secured in the sockets 24 of the nozzle body 20 preferably by a threaded engagement with an O-ring disposed between the insert 12, 16 and the internal walls of the socket 24 to form a fluid tight seal. Other mechanical or fit connections can be made to secure the inserts within the sockets. Each socket 24 includes preferably narrowed bores 26a, 26b, 26c, 26d, 26e extending between the socket 24 and the central bore 22 along a lateral axis to provide fluid communication between the central bore 22 and the corresponding socket 24. Lateral bores 26a, 26b, 26c, 26e extend preferably obliquely with respect to the central nozzle longitudinal axis A--A to define a preferred included angle Θ of 45°-60°, more preferably about 50° with the nozzle axis. In a preferred embodiment, the preferred included angle Θ even more preferably is 52°. The body 20 preferably includes a socket 24d formed coaxially along the central nozzle axis A--A and placed in fluid communication with the central bore 22 by an axially aligned narrowed bore 26d.

[0022] The nozzle body 20 is preferably received within a socket fitting 40. The socket fitting 40 has an internal passageway 42 placed in fluid communication with the central bore 22 of the nozzle body 20. Preferably disposed between the internal passageway 42 of the socket fitting 40 and the central bore 22 is a filter 45 to filter out any particles in the fluid. Additionally disposed between the socket fitting 40 and the nozzle body 20 is an O-ring 47 to form a fluid tight connection.

[0023] At the end of the socket fitting 40 opposite the nozzle body 20 is an inlet insert or ferrule 50 to form the fluid inlet of the device 10. The ferrule 50 is preferably secured to the

socket fitting by a hex nut 60. Preferably, the ferrule insert 50 provides for an inlet of a constant width or diameter that is in fluid communication with a preferably tapering portion of the internal passageway 42 of the socket fitting 40. A firefighting fluid supply line (not shown) can be inserted into the ferrule 50 and socket fitting 40 and secured by tightening the internally threaded hex nut to the externally threaded socket fitting 40. Fluid introduced at the ferrule inlet 50 flows through the filter 45 and into the central bore 22 of the nozzle body 20 through the lateral bores 26 and for delivery at an operative pressure to each of the orifice inserts 12, 16 for fluid discharge in a desired manner.

[0024] The water mist nozzle shown in FIGS. 3A and 3B is an open nozzle in which water delivered to the water mist device 10 at operating pressure is immediately discharged from the orifice inserts 12, 16. Alternate embodiments of a water mist device can be provided for automated operation in which the nozzle device is initially in an unactuated or “closed” state and then triggered or actuated to an open state for discharging the fluid. Shown in FIG. 4 is an alternate embodiment of a water mist device 210 in which the discharge from the device is controlled by a thermally responsive trigger 250. A piston 252 is disposed within the central bore 222 of the body 240 below the filter 245. The trigger 250 is seated against a trigger bracket or support 256 that is affixed to the nozzle body 220 and axially aligned with the central bore 222. The trigger 250 supports the piston 252 in an unactuated position within the central bore 222. O-rings 251 disposed about the piston 252 prevent the flow of water from the inlet to the lateral bores 226.

[0025] The trigger 250 is thermally responsive and preferably embodied as a thermally responsive bulb of a desired thermal rating and responsiveness. When the bulb 250 is actuated and triggered at its designated thermal rating in the presence of a sufficient level of heat, the bulb

shatters thereby removing support of the piston 252. The piston then axially translates under the pressure of water. With the piston 252 clear of the lateral bores, water is delivered to each of the obliquely disposed orifice inserts 212, 216 for generation and distribution of a fluid mist and spray in a manner as previously described.

[0026] Shown in FIGS. 5A-5C are various views of a preferred embodiment of a direct impingement orifice insert 16 for providing a fluid discharge for directly addressing a fire with a mist and/or spray. Generally, the direct impingement orifice insert 16 is a cylindrical body having a first end 16a and a second end 16b. Formed at the first end 16a is at least one inlet and more preferably a single centered inlet 15 into which the firefighting fluid is introduced; and at the second end 16b are at least one and preferably more than one outlet 18 from which the fluid is discharged. Extending between the inlet 15 and the outlet 18 is an internal chamber 17 extending axially between the inlet 15 and the at least one outlet 18 along a central insert axis B--B. The orifice inserts described herein are preferably disposed within the sockets of the body so as to axially align the insert axis B-B with the lateral bores to intersect the central longitudinal nozzle axis. The chamber 17 is preferably defined by an internal wall 17a of the device that is preferably circumscribed about the insert axis B--B to define a preferred cylindrical chamber with an internal diameter *DIA* ranging between 7-8 millimeters (0.28-0.3in) and is preferably 7.5 millimeters (0.29 in.). The chamber 17 extends from the inlet 15 to a floor 17b of the chamber 17 at a chamber depth or height *H* of 8-9 millimeters (0.3-0.35 in.), preferably about 8.5 millimeters (0.33 in.) and more preferably 8.7 millimeters (0.34 in.). For the preferably single coaxially aligned central inlet 15, the inlet 15 is preferably dimensioned to define an internal diameter of 7.5 millimeters (0.29 in.). Generally, the orifice insert has a preferred maximum

diameter D of about 15 millimeters (0.59 in.) and a total height or length L of about 12 millimeters (0.47 in.).

[0027] Preferably extending through the chamber floor 17b of the orifice insert 16 are the one or more outlets 18. Preferably formed about the central insert axis B--B are four spaced apart outlet passageways 18. Each preferably straight outlet 18 extends obliquely to define an included angle β with the central insert axis B--B that preferably ranges from 10°-60° and is preferably about 25° and is more preferably 22°-22.5°. Other alternate preferred included angles β includes 15° and 22.5°. Each outlet defines an outlet diameter and configuration to generate discharge characteristics such as, for example, a desired droplet size. In a preferred embodiment, each of the outlets 18 define an outlet diameter OD of about 0.5-1.0 millimeters (0.02-0.04 in.) and is more preferably 0.7 millimeters (0.03 in.). Given the preferred coaxially alignment of the inlet 15 and chamber 17 with the outlets formed along the chamber floor 17b and continuous wall 17a, the fluid flow through the chamber 17 preferably has no, or a minimized, swirling effect within the chamber 17 to maximize the direct discharge or impingement. In preferred embodiments of the nozzle device 10, the preferred direct impingement orifice insert 16 discharges a fluid mist with a droplet size that is greater than the droplet size of the fluid mist discharged from the indirect impingement orifice insert 12.

[0028] Shown in FIGS. 6A-6C are various views of an exemplary embodiment of an indirect impingement orifice insert 12 preferably for providing a fluid discharge for total flooding, cooling and/or wetting of the surrounding environment of the device 10. Generally, the indirect impingement orifice insert 12 is a cylindrical body having a first end 2a and a second end 2b. Formed at the first end 2a is at least one inlet and more preferably multiple inlets and even more preferably a pair of inlets 35a, 35b into which the firefighting fluid is introduced; and at the

second end 2b are at least one and preferably a single centered outlet 38 from which the fluid is discharged. An internal chamber 37 extends axially between the inlets 35a, 35b and the outlet 38 along a central insert axis BB--BB. The chamber 37 is preferably defined by an internal wall 37a of the device that is preferably circumscribed about the insert axis BB--BB to define a preferred cylindrical chamber with an internal diameter *DIA2* ranging between 7-8 millimeters (0.28-0.3in) and is preferably 7.5 millimeters (0.29 in). More preferably, the internal diameter *DIA2* varies between the diameter over the depth of the chamber 37. The chamber 37 extends from the inlets 35a, 35b to a floor 37b of the chamber 37 at a chamber depth or height *H2* of 4-9 millimeters (0.16-0.35 in.), preferably about 5 millimeters (0.2 in.) and more preferably 4.9 millimeters (0.19 in.). Generally, the preferred total flooding orifice insert 12 has a preferred maximum diameter *D2* of about 15 millimeters (0.59 in.) and a total height or length *L* of about 12 millimeters (0.47 in.). Preferably extending through the chamber floor 37b of the orifice insert 12 is the outlet 38 centrally aligned with the insert axis BB--BB, which defines an outlet diameter to generate discharge characteristics such as, for example, the mist having the desired droplet size. In a preferred embodiment, the outlet 38 define a preferred outlet diameter *OD2* of about 0.5-1 millimeters (0.02-0.04 in.) and is more preferably 0.8 millimeters (0.03 in.).

[0029] The floor 37b preferably is angled or tapers toward the outlet 38 and more preferably defines a conical surface with a preferred cone angle of 120°. The conical internal surface or floor 37b of the chamber facilitates a preferred swirling effect in the fluid through the internal chamber 37 before fluid discharge. To further facilitate the swirling effect, the inlets 35a, 35b each include a transverse portion 33a, 33b that extends transversely with respect to the insert axis BB--BB and the outlet 38. Moreover, the transverse portions 33a, 33b extend in opposed directions and more preferably are disposed to discharge fluids therefrom substantially

tangentially with respect to the chamber 37 such that the fluid introduced into the chamber 37 generate a countercurrent flow and the preferred swirling effect. For the preferred chamber 37, the inlets 35a, 35b are preferably dimensioned to range from 1.5 - 2 millimeters (0.06-0.08 in.) and more preferably range from 1.6 -2 millimeters. In the installation of the orifice inserts 12 shown in FIGS. 3A, 3B and 6C, a cap member 65 is inserted in the first end 2a of the orifice insert 12 to plug the chamber 37 and divert fluid from the central and lateral bores 22, 26 toward the inlets 35a, 35b. Accordingly, in a preferred embodiment of the orifice insert 12 with a cap member 65 inserted therein, the inlets 35a, 35b are located at the periphery of the cap member 65.

[0030] The orifice inserts 12, 16 of the device 10 together provide for a discharge characteristic of flow to pressure which can be quantified by a K-factor of $0.1 \text{ gpm/psi}^{(1/2)}$ and more preferably $0.107 \text{ gpm/psi}^{(1/2)}$. The device 10 has a preferred operating pressure ranging from 1000 psi. to 1100 psi. Alternative configurations of the device 10 can have lower or more preferably higher operating pressures. The water mist nozzle devices 10 individually provide for a preferred fluid discharge of indirect impingement (total flooding) and direct impingement mist spray. Collectively, the nozzles provide a desired fluid distribution density. In one water distribution arrangement schematically shown in FIG. 7, two water mist nozzles 110a, 110b as previously described, were installed and located five feet apart and ten feet (10ft.) above the ground. Each of the nozzles 110a, 110b were angled downward at a preferred downward angle α of 5° - 20° and more preferably 8° - 18° with the angles being different from one another. In the distribution arrangement, one nozzle is preferably oriented at 8° and the other is oriented at 18° . Positioned in front of the nozzles were seven rows of five 1 ft. x. 1 ft. collection pans. Water was distributed for 10 minutes and the amount of water collected in each bucket was determined

and plotted as shown in FIG. 7. In the preferred water distribution, a density of 0.12 gpm/sq. ft. of water was collected in a collection bucket located between the two nozzles three feet in front and three feet offset from the left most nozzle 110a. The distribution testing shows that more water is concentrated in the areas where the potential fires could be located between nozzle devices. Moreover, in addressing a fire with the preferred nozzle devices 10, the water mist discharged from the angled outlets 18 of the preferred direct impingement orifice insert 16 facilitates in the suppression and/or control of the fire with the larger sized droplets that penetrate the fire plume. The tiny droplets of the water mist discharged from the indirect impingement orifice inserts 12 provide cooling of the upper gas layer above and/or proximate the fire. Thus, the innovative nozzle device and methods of addressing a fire for equipment and occupied spaces provide a mist for indirect impingement, which includes total flooding of equipment and/or occupied space; and direct impingement, which includes penetration of a plume of a fire within the equipment and/or occupied space.

[0031] While the present invention has been disclosed with reference to certain embodiments, numerous modifications, alterations, and changes to the described embodiments are possible without departing from the sphere and scope of the present invention, as defined in the appended claims. Accordingly, it is intended that the present invention not be limited to the described embodiments, but that it has the full scope defined by the language of the following claims, and equivalents thereof.

What is Claimed Is:

1. A water mist nozzle comprising:

a body having a central bore extending along a central longitudinal nozzle axis, the body including a plurality of sockets formed about the central bore, each socket including a lateral bore extending between the socket and the central bore along a lateral axis; and

a plurality of orifice inserts, each orifice insert having at least one inlet, at least one outlet and an internal chamber disposed along a central insert axis for fluid communication with the at least one inlet and the at least one outlet, each orifice insert being disposed in one of the plurality of sockets so as to axially align the insert axis with the lateral bore of the socket obliquely intersecting the central longitudinal nozzle axis, the plurality of orifice inserts including indirect impingement orifice inserts and at least one direct impingement orifice insert.

2. The nozzle of claim 1, wherein the at least one inlet of the direct impingement orifice is a single inlet extending coaxially with the insert axis.

3. The nozzle of claim 1, wherein the at least one outlet of the direct impingement orifice inserts includes a plurality of outlets surrounding the insert axis.

4. The nozzle of claim 3, wherein each of the plurality of outlets of the direct impingement orifice insert extends obliquely with respect to the insert axis to define an included angle ranging from 20°-25°.

5. The nozzle of any one of claims 3-4, wherein the plurality of outlets of the direct impingement orifice insert include four outlets.

6. The nozzle of any one of the above claims, wherein the direct impingement orifice insert defines an installation orientation with respect to a ground such that the direct impingement orifice insert is oriented to the ground with the nozzle axis being disposed at an downward angle ranging from 5° - 20° with respect to a horizontal parallel to ground.
7. The nozzle of claim 6, wherein the downward angle ranges from 8° - 18° .
8. The nozzle of any one of the above claims, wherein the body includes a socket axially aligned with the nozzle axis in communication with the central bore, the nozzle further comprising a central orifice insert axially aligned with the nozzle axis.
9. The nozzle of claim 8, wherein the central orifice insert is a direct impingement orifice insert.
10. The nozzle of claim 8, wherein the central orifice insert is an indirect impingement orifice insert.
11. The nozzle of any one of the above claims, wherein the indirect impingement orifice insert includes at least one inlet with a portion extending transversely with respect to the insert axis and in fluid communication with the internal chamber.
12. The nozzle of claim 11, wherein the at least one inlet includes a plurality of inlets of the orifice insert of the first type having a pair of inlets disposed about the insert axis with the transversely extending portions extending in opposite directions.

13. The nozzle of claim 12, wherein the chamber is defined by an internal wall circumscribed about the insert axis, the transversely extending portions being disposed to discharge fluids therefrom substantially tangentially.

14. The nozzle of any one of the above claims, wherein the indirect impingement orifice insert includes a cap member disposed within the internal chamber, the at least one inlet being disposed about the periphery of the cap member.

15. The nozzle of any one of the above claims, wherein the at least one inlet of the direct impingement orifice insert extends substantially parallel to the insert axis.

16. The nozzle of any one of the above claims, wherein the plurality of orifice inserts includes three indirect impingement orifice inserts and one direct impingement orifice insert equiangularly spaced about the nozzle axis.

17. The nozzle of any one of the above claims, wherein the nozzle is an open nozzle.

18. The nozzle of any one of the above claims, wherein the nozzle is an automatic nozzle, the nozzle including a piston disposed in the central bore and a thermally responsive trigger supporting the piston within the central bore to prevent fluid discharge from the nozzle.

19. The nozzle of any one of the above claims, wherein the nozzle has a discharge characteristic quantified by a K-factor of about K-factor of $0.1 \text{ gpm/psi}^{(1/2)}$.

20. A water mist nozzle comprising:

a body having a central bore extending along a central longitudinal nozzle axis, the body including a plurality of sockets formed about the central bore, each socket including a lateral bore extending between the socket and the central bore along a lateral axis; and

a plurality of orifice inserts, each orifice insert having at least one inlet, at least one outlet and an internal chamber extending axially between the at least one inlet and the at least one outlet along a central insert axis, each orifice insert being disposed in one of the plurality of sockets so as to axially align the insert axis with the lateral bore of the socket obliquely intersecting the central longitudinal nozzle axis, the plurality of orifice inserts including orifice inserts of a first type and orifice inserts of at least a second type different than the first type, the at least one inlet of the first type of orifice insert including a plurality of inlets having a portion extending transversely with respect to the insert axis, the at least one inlet of the second type of orifice being coaxially aligned with the insert axis.

21. The nozzle of claim 20, wherein the at least one outlet of the second type of orifice insert includes a plurality of outlets surrounding the insert axis.

22. The nozzle of claim 21, wherein each of the plurality of outlets of the second type of orifice insert extend obliquely with respect to the insert axis to define an included angle ranging from 20°-25°.

23. The nozzle of any one of claims 21-22, wherein the plurality of outlets of the second type of orifice insert include four outlets.

24. The nozzle of any one of claims 20-23, wherein the at least one outlet of the first type of orifice insert includes an outlet axially aligned with the insert axis.

25. The nozzle of any one of claims 20-24, wherein the plurality of inlets of the orifice insert of the first type include a pair of inlets disposed about the insert axis with the transversely extending portions extend in opposite directions.
26. The nozzle of any one of claims 20-25, further comprising a cap disposed within the internal chamber of the inserts of the first type.
27. The nozzle of any one of claims 20-26, further comprising a central orifice insert axially aligned with the nozzle axis.
28. The nozzle of claim 27, wherein the central orifice insert is of the first type.
29. The nozzle of claim 27, wherein the central orifice insert is of the second type.
30. The nozzle of any one of claims 20-29, wherein the plurality of orifice inserts includes three orifice inserts of the first type and one orifice insert of the second type equiangularly spaced about the nozzle axis.
31. The nozzle of any one of claims 20-30, wherein the second type of orifice insert defines a nozzle orientation with respect to a ground such that the orifice insert of the second type is oriented to the ground with the nozzle axis being disposed at an downward angle ranging from 5°-20° with respect to a horizontal parallel to the ground.
32. The nozzle of any one of claims 20-31, wherein the nozzle is an open nozzle.
33. The nozzle of any one of claims 20-32, wherein the nozzle is an automatic nozzle, the nozzle including a piston disposed in the central bore and a thermally responsive trigger supporting the piston within the central bore to prevent fluid discharge from the nozzle.

34. The nozzle of any one of claims 20-33, wherein the nozzle has a discharge characteristic quantified by a K-factor of about K-factor of $0.1 \text{ gpm/psi}^{(1/2)}$.

35. A water mist nozzle comprising:

a body having a central bore extending along a central longitudinal nozzle axis; and

a plurality of orifice inserts disposed about the central bore, each orifice insert having at least one inlet, at least one outlet and an internal chamber extending axially between the inlet and the at least one outlet along a central insert axis, the plurality of orifice inserts including orifice inserts of a first type and orifice inserts of at least a second type, the at least one outlet of the first type of orifice insert being axially aligned along the insert axis, the at least one outlet of the second type of orifice insert including a plurality of outlets surrounding the insert axis, each extending obliquely with respect to the insert axis.

36. The nozzle of claim 35, wherein the second type of orifice insert defines a nozzle orientation with respect to a ground such that the orifice insert of the second type is oriented to the ground with the nozzle axis being disposed at an downward angle ranging from 5° - 20° with respect to a horizontal parallel to ground.

37. The nozzle of claim 36, wherein the downward angle ranges from 8° - 18° .

38. The nozzle of any one claims 35-37, wherein the nozzle is an open nozzle.

39. The nozzle of any one of claims 35-38, wherein the nozzle is an automatic nozzle, the nozzle including a piston disposed in the central bore and a thermally responsive trigger supporting the piston within the central bore to prevent fluid discharge from the nozzle.

40. The nozzle of any one of claims 35-39, wherein the plurality of outlets of the second type of orifice insert discharges a mist with a droplet size greater than the droplet size of a mist discharged from the outlet of the first type of orifice.

41. A water mist nozzle comprising:

a body having a central bore extending along a central longitudinal nozzle axis; and

a plurality of nozzles disposed about the central bore including a plurality of indirect impingement nozzles and at least one direct impingement nozzle.

42. The nozzle of claim 41, wherein the nozzle is an open nozzle.

43. The nozzle of claim 41, wherein the nozzle is an automatic nozzle, the nozzle including a piston disposed in the central bore and a thermally responsive trigger supporting the piston within the central bore to prevent fluid discharge from the nozzle.

44. The nozzle of claim any one of claims 41-43, wherein the at least one direct impingement nozzle is configured to generate a mist with a droplet size greater than a droplet size of a mist generated by the at least one indirect impingement nozzle.

45. A method of water mist nozzle protection comprising:

generating a first type of fluid mist from a first type of orifice insert disposed in one of a plurality of sockets formed in a nozzle body into which a firefighting fluid is introduced; and

generating a second type of fluid mist from a second type of orifice insert disposed in another one of the plurality of sockets formed in the nozzle body, the second type of fluid mist having a droplet size that is greater than the first type of fluid mist to directly impinge a fire.

46. The method of claim 45, wherein the generating the second type of fluid mist includes introducing the firefighting fluid into an inlet and through an internal chamber extending along an insert axis of the second type of orifice insert; and discharging the fluid out at least one outlet extending through a floor of the chamber of the second type of orifice insert.

47. The method of claim 46, wherein discharging the fluid out at least one outlet includes discharging the fluid out a plurality of openings.

48. The method of claim 47, wherein the discharging include discharging out of the plurality of openings obliquely with respect to define at an included angle ranging from 22° - 22.5° .

49. The method of any one of claims 45-48, wherein generating the first type of fluid mist includes introducing the firefighting fluid into an inlet and through an internal chamber with a swirling effect.

50. A method of water mist nozzle protection comprising:

installing at least two water mist nozzles above a ground to protect an area or object, each nozzle having a plurality of orifice inserts about a nozzle axis with at least one orifice insert configured for generating a first mist to address a fire with indirect impingement and at least one orifice insert facing the floor and configured for generating a second mist to address a fire with direct impingement; and

orienting each nozzle so that the nozzle axes of the at least two nozzles define an included angle ranging from 5° - 20° with respect to a horizontal parallel to ground, the included angles of the at least two nozzles being different from one another.

51. The method of claim 50, wherein each of the at least two nozzles is oriented one of 8° or 18° ,

52. The method of claim 51, wherein the installing includes spacing the at least two nozzles five feet apart and disposed ten feet (10ft.) above the ground to define a collection density of 0.12 gpm/sq ft. of water between the two nozzles three feet in front and three feet offset from one of the two nozzles.

53. The method of any one of claims 50-52, wherein the generating the second mist includes generating a droplet size greater than a droplet size of the first mist, generating the second mist includes introducing the firefighting fluid into an inlet and through an internal chamber extending along an insert axis of the at least one orifice insert facing the floor; and discharging the fluid out at least one outlet extending through a floor of the chamber.

54. The method of claim 53, wherein discharging the fluid out at least one outlet includes discharging the fluid out a plurality of openings.

55. The method of claim 54, wherein the discharging include discharging out of the plurality of openings obliquely with respect to define at an included angle ranging from 22° - 22.5° .

56. The method of any one of claims 50-55, wherein generating the first mist includes introducing the firefighting fluid into an inlet and through an internal chamber with a swirling effect.

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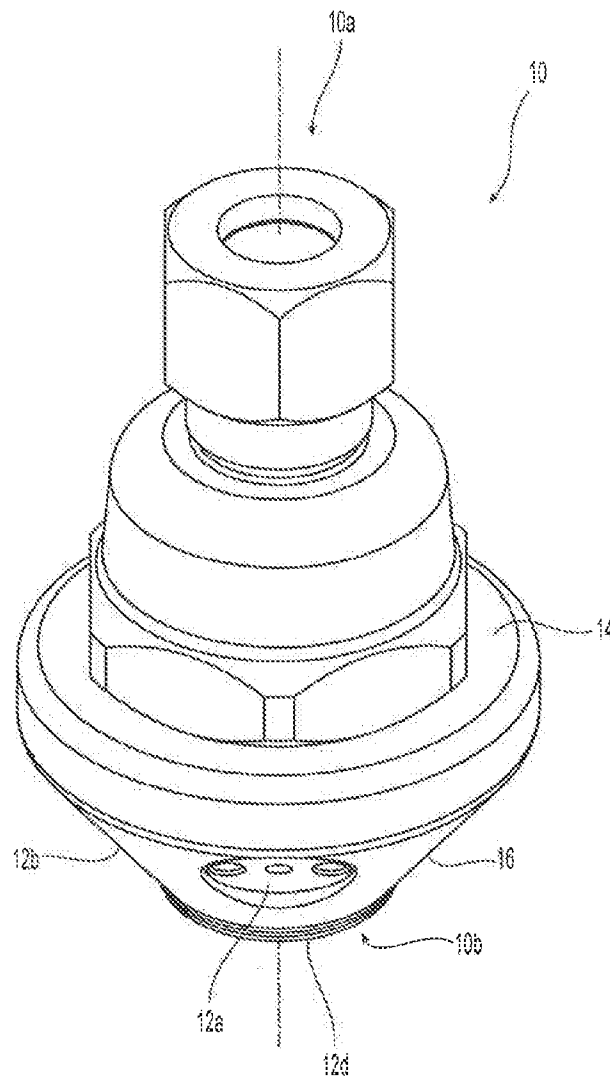
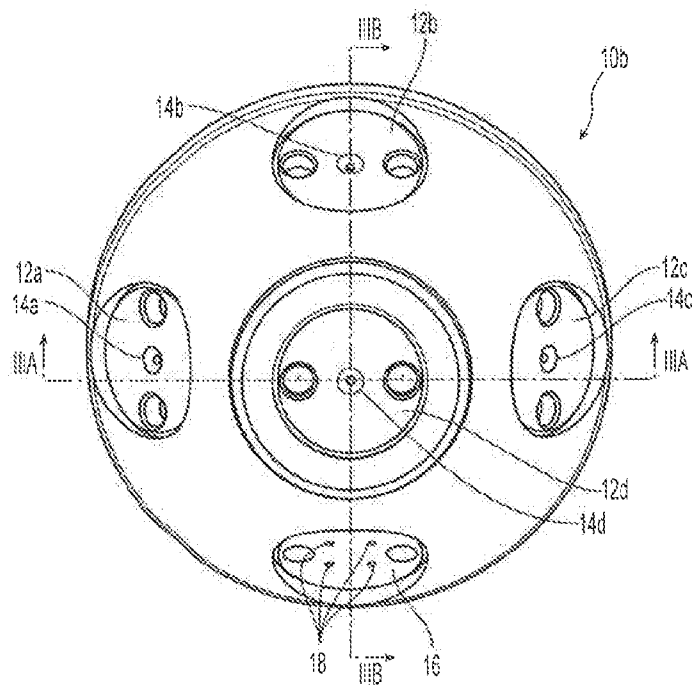
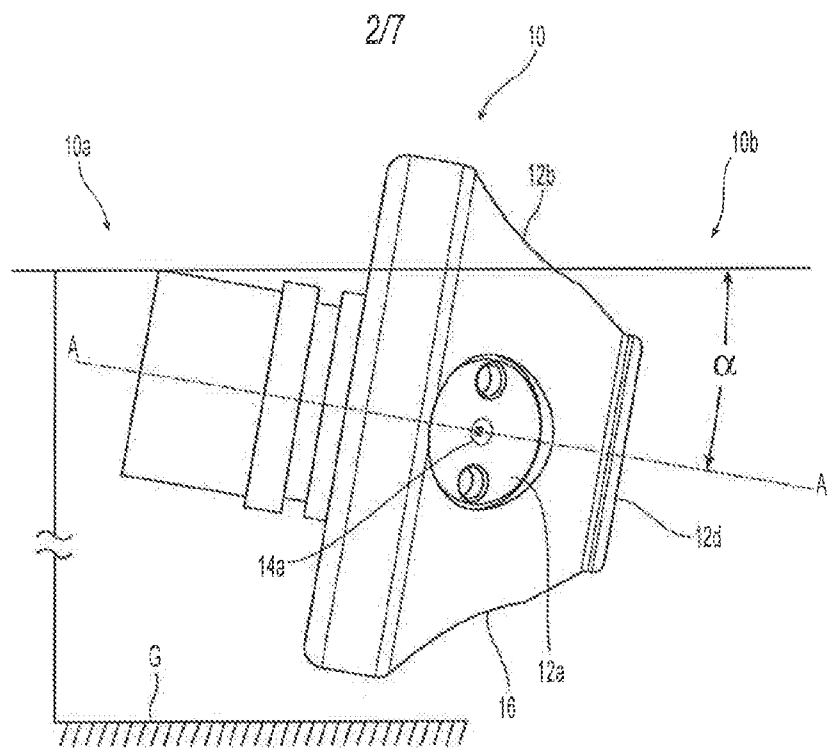


Fig. 1



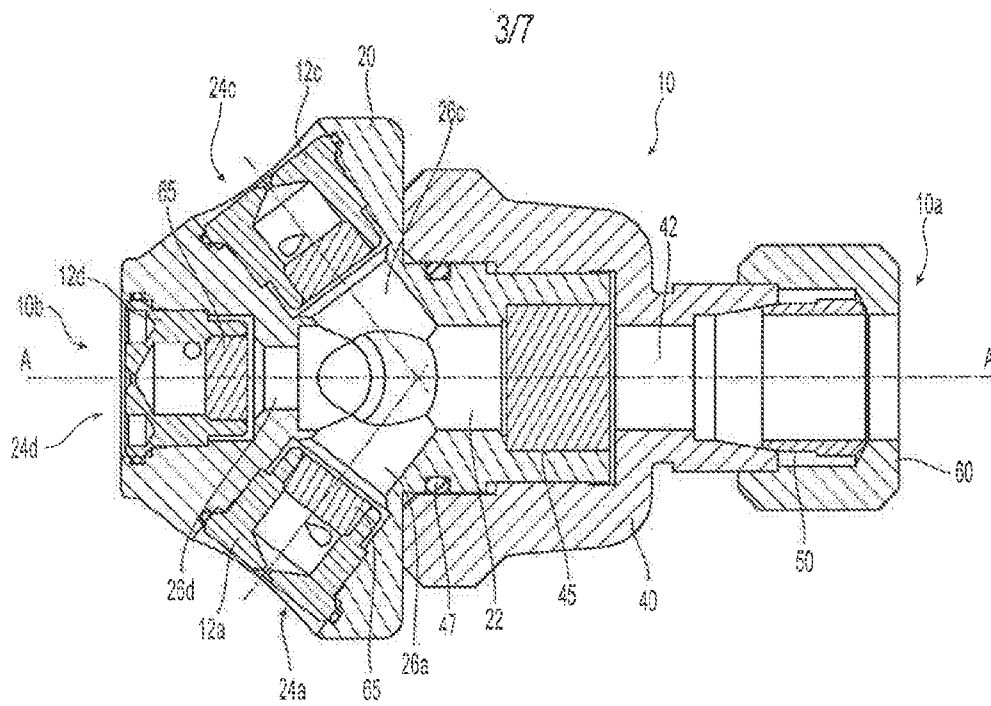


Fig. 3A

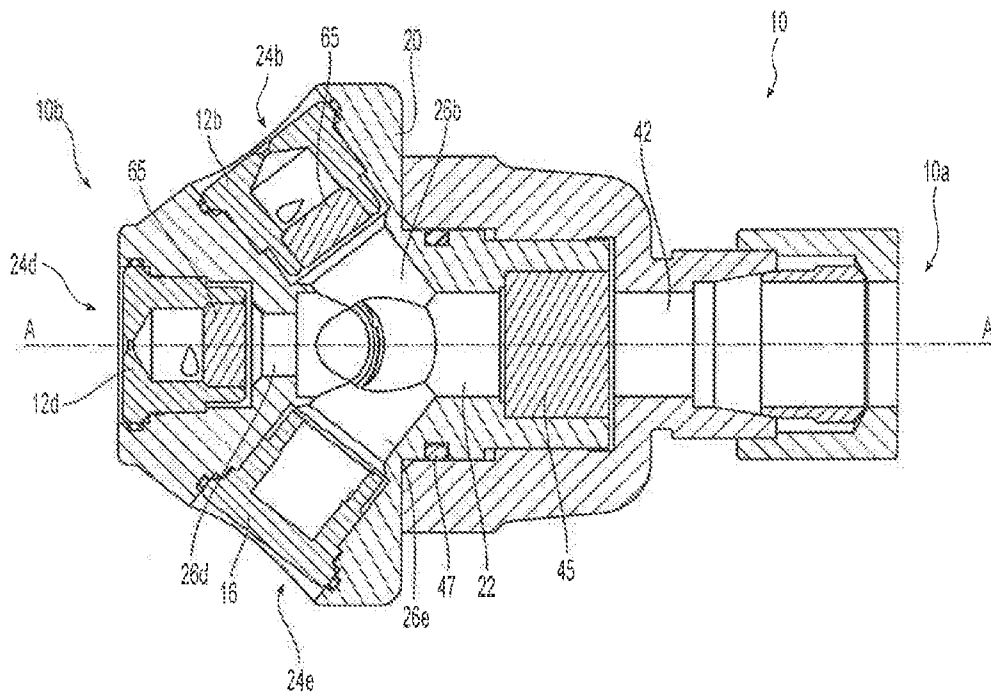


Fig. 3B

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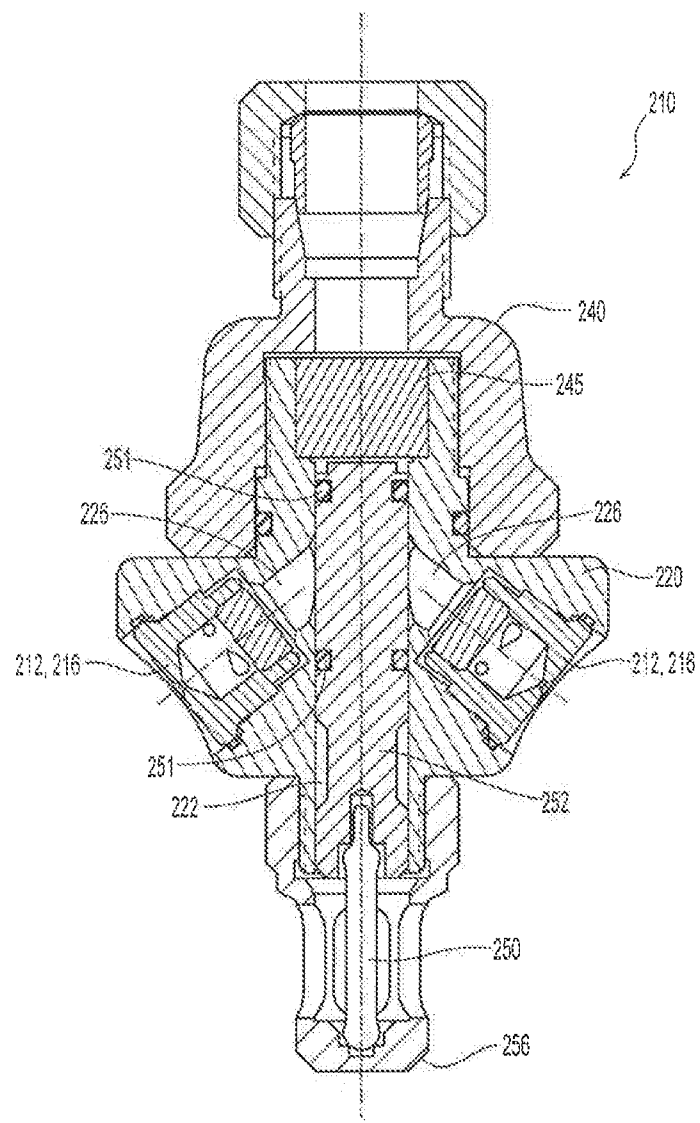


Fig. 4

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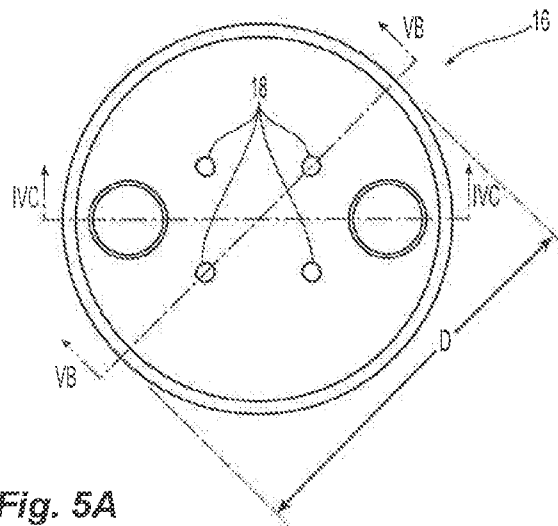


Fig. 5A

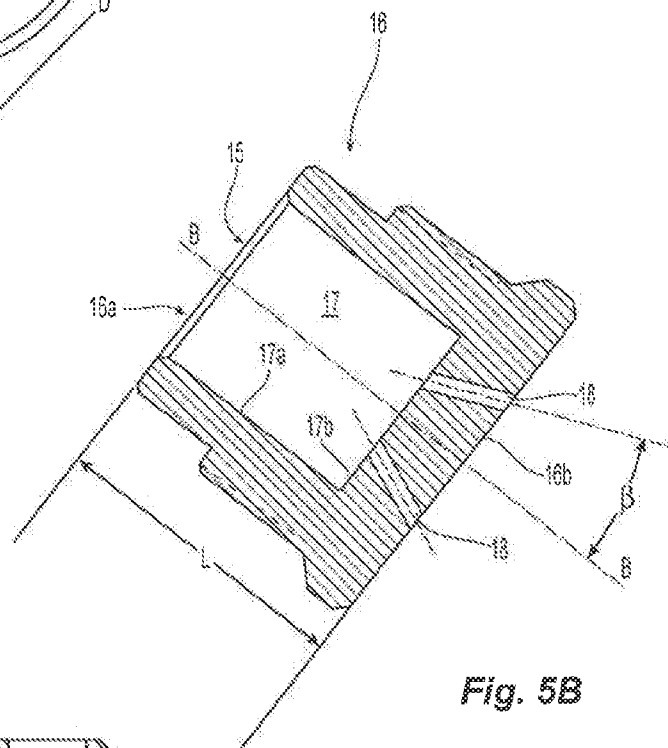


Fig. 5B

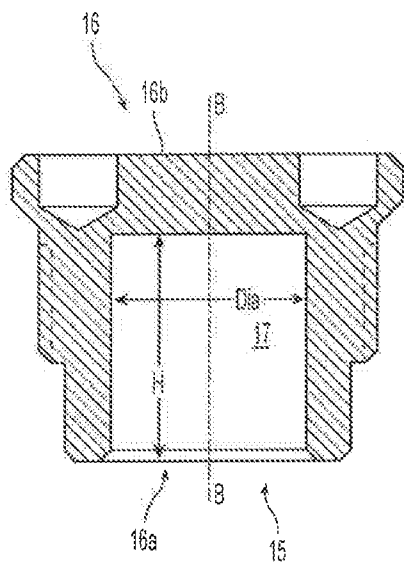


Fig. 5C

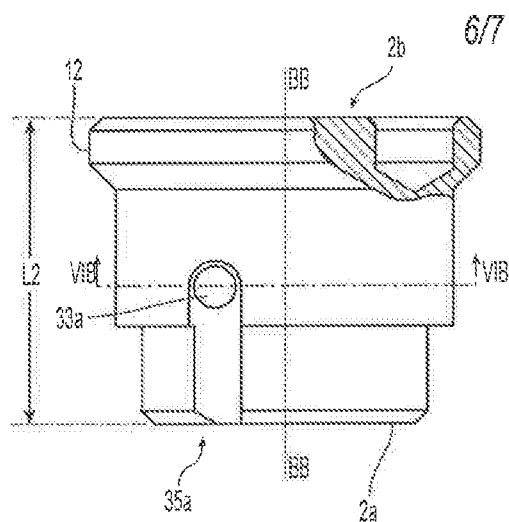


Fig. 6A

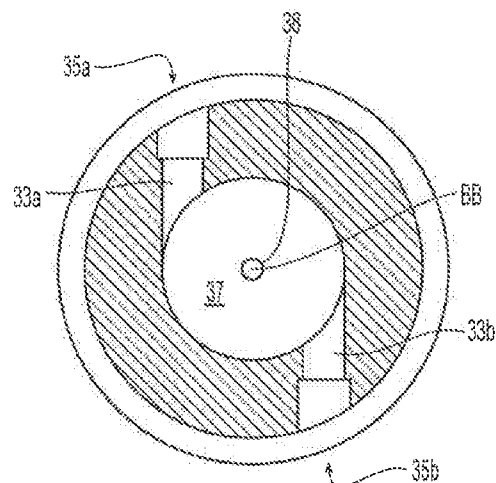


Fig. 6B

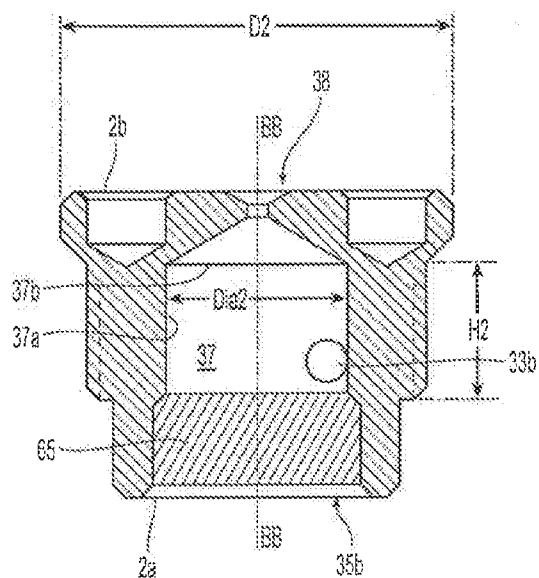
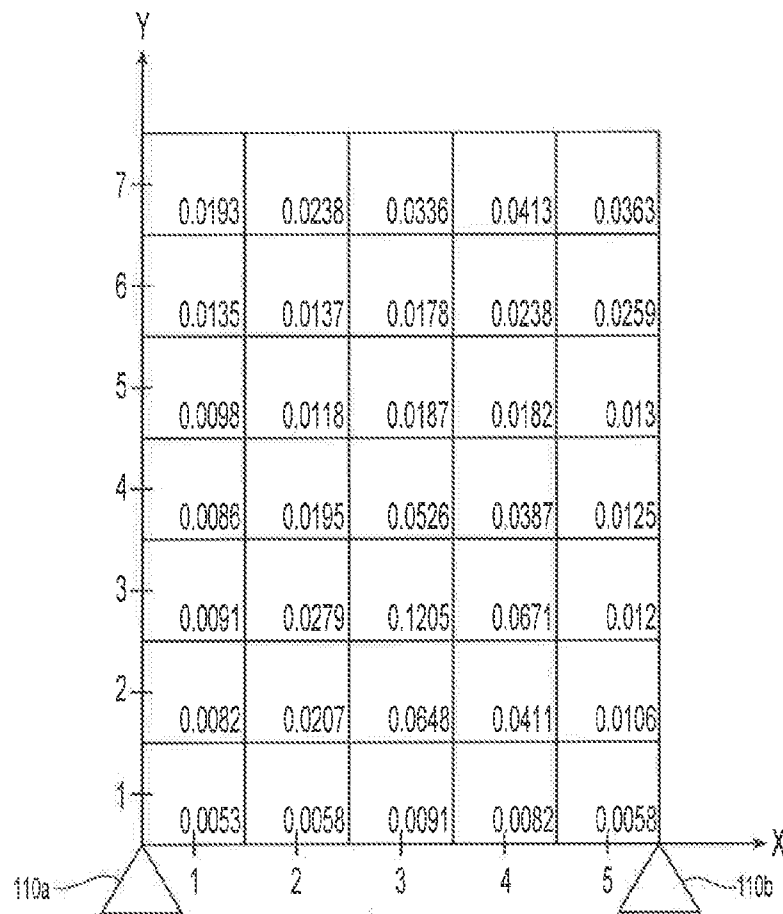


Fig. 6C

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**Fig. 7**

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/040347

A. CLASSIFICATION OF SUBJECT MATTER
INV. A62C37/14 A62C31/05 B05B1/20 B05B1/34 B05B1/14
ADD.

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)
A62C B05B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2006/086831 A1 (TSAI RONG-FENG [TW] ET AL) 27 April 2006 (2006-04-27)	1,2, 6-20, 24-32, 34,41, 42, 44-46, 49-53,56
Y	paragraphs [0029], [0050], [0051],	3-5,22
A	[0053]; claim 16; figures 1,4,8 paragraph [0006]; figures 13,14	48
X	WO 2016/059561 A1 (ETEA SICUREZZA GROUP LTD [GB]) 21 April 2016 (2016-04-21)	35, 39-41, 43-47
A	page 3, lines 3-11 - page 6, lines 13-25; claims 1,5, 12; figures 1,2,8	1,18,20, 22,23,48
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Further documents are listed in the continuation of Box C.



See patent family annex.

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"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

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"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

"&" document member of the same patent family

Date of the actual completion of the international search

13 September 2017

Date of mailing of the international search report

22/09/2017

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Marin, Charles

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/040347

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	CN 104 667 466 A (SHANGHAI JINDUN FIRE FIGHTING SECURITY TECHNOLOGY CO LTD; SHANGHAI JIN) 3 June 2015 (2015-06-03) Automatic translations claims 2,4: 2. fine mist spray head according to claim 1, it is characterized in that: described straight atomization nozzle (4) is for comprising the cavity of a water inlet and more than one apopore (5), and the water inlet of described straight atomization nozzle (4) is connected with described pipelined channel (3). 4. ... according to ... claims 1 to 3 described in any one, it is characterized in that: described vortex atomizing nozzle (2) comprises a cavity (6) and an atomization core (7) be arranged in described cavity (6), this cavity (6) comprises a water inlet and an apopore, the water inlet of described vortex atomizing nozzle (2) is connected with described pipelined channel (3), and described atomization core (7) can make water under high pressure form water mists at apopore.; claims 2,4; figures 1-4 -----	34,35, 39-41, 43-47,49 3-5,22 1,2,8,9, 11-13, 15,18, 20,21, 23-25, 27,29, 33,48
X Y A	JP H08 266676 A (NOHMI BOSAI LTD) 15 October 1996 (1996-10-15) figures 1-7 -----	1,6-8, 11-17, 19,20, 24-26, 41,42, 44-46 3-5 36,37
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X A	WO 00/15303 A1 (FOGTEC BRANDSCHUTZ GMBH [DE]; KAMMER PETER [CH]; ITIN BEDA [CH]) 23 March 2000 (2000-03-23) claims 1,5, 9; figures 1-3 ----- -/--	35,41, 45-47,49 1-4,48

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2017/040347

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	CN 2 677 039 Y (ZHONG JIQIANG [CN]) 9 February 2005 (2005-02-09) claims 1,4; figures 2-7	41,42, 44-46,49 1,2,8,9, 11-17, 20, 24-29, 32,35
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