It was later discovered that the primary cause of damage to the hard disks was not the exposure to the fire-suppressing gas agent, but rather noise that accompanied the accidental triggering of the fire-suppression system. *See*, "Fire Suppressant's Impact on Hard Disks," *Availability Digest*, February 2011. Subsequent testing also showed that loud noises, such as those generated by the activation of the fire-suppression system, can reduce the performance of hard disk drives by up to 50%, resulting in temporary disk malfunction and damage to disk sectors. Thus, the foregoing incident shed light on the problem of noise levels during activation of inert gas fire-suppression systems, and the need for controlling noise in order to adequately protect sensitive computer equipment.

SUMMARY OF THE INVENTION

In one embodiment ~~according to the present invention~~, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system. The nozzle generally comprises a nozzle housing having a gas inlet and a gas outlet and at least a first innermost partition and a second outer partition located within the housing. The first partition defines an inner gas-receiving chamber into which a gas flowing through the gas inlet is received. The first and second partitions cooperate to define a first annular region therebetween. The first annular region being fluidly connected with the inner gas-receiving chamber by a first passage located at the distal end of the first partition. The partitions are configured such that the gas flows in the first annular region in an opposite direction to the gas flowing in the inner gas-receiving chamber. The second partition partially defines a second annular region outboard of the second partition. The second annular region is fluidly connected with the first annular region by a second passage located opposite from the first passage. The second annular region is configured such that the gas flows in the second annular region toward the gas outlet in an opposite direction to the gas flowing in the first annular region.

In another embodiment ~~according to the present invention~~, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system. The nozzle generally comprises a nozzle housing having a gas inlet and a gas outlet, a plurality of generally cylindrical partitions located within the housing, and a nozzle stem operable to conduct a gas into the interior of the nozzle. The plurality of partitions cooperate to define a flow path for the gas as it flows between the gas inlet and the gas outlet and includes an innermost partition

defining an inner gas-receiving chamber. The nozzle stem comprises an axial bore formed therein and operable to conduct gas through the gas inlet into the inner gas-receiving chamber. The flow path is configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from the gas outlet.

In yet another embodiment ~~according to the present invention~~, there is provided an inert gas hazard-suppression system comprising a pressurized source of an inert gas, conduit for directing a flow of the inert gas from the source to an area protected by the system, and a nozzle according to any embodiment described herein coupled with the conduit for introducing the flow of the inert gas into the area protected the system.

In still another embodiment ~~according to the present invention~~, there is provided a method of reducing the sound waves generated by the discharge of a gas from a hazard-suppression system. The method generally comprises detecting a hazardous condition within an area to be protected by the suppression system, initiating a flow of the gas from a pressurized gas source toward the area to be protected, directing the flow of gas through a nozzle having a gas inlet fluidly connected with a gas outlet by a gas flow path, and discharging the gas from the gas outlet into the area to be protected. The flow path within the nozzle causes the gaseous material to alternate between flowing a direction toward and a direction away from the gas outlet.

In one aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; and at least a first innermost partition and a second outer partition located within said housing, said first partition defining an inner gas-receiving chamber into which a gas flowing through said gas inlet is received, said first and second partitions cooperating to define a first annular region therebetween, said first annular region being fluidly connected with said inner gas-receiving chamber by a first passage located at the distal end of said first partition, said partitions being configured such that the gas flows in said first annular region in an opposite direction to the gas flowing in said inner gas-receiving chamber, said second partition partially defining a second annular region outboard of said second partition, said second annular region being fluidly connected with said first annular region by a second passage located opposite from said first passage, said second annular region being configured such that the gas flows in said second annular region toward said gas outlet in an opposite direction to the gas flowing in said first annular region.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; a plurality of generally cylindrical partitions located within said housing, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber; and a nozzle stem having an axial bore formed therein and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet.

In another aspect, there is provided an inert gas hazard-suppression system comprising: a pressurized source of an inert gas; conduit for directing a flow of said inert gas from said source to an area protected by said system; and a nozzle as defined herein coupled with said conduit for introducing the flow of said inert gas into the area protected the system.

In another aspect, there is provided an inert gas hazard-suppression system comprising: a pressurized source of an inert gas; conduit for directing a flow of said inert gas from said source to an area protected by said system; and a nozzle as defined herein coupled with said conduit for introducing the flow of said inert gas into the area protected the system.

In another aspect, there is provided a method of reducing the acoustic energy generated by the discharge of a gas from a hazard-suppression system comprising: detecting a hazardous condition within an area to be protected by said suppression system; initiating a flow of said gas from a pressurized gas source toward said area to be protected; directing said flow of gas through a nozzle having a gas inlet fluidly connected with a gas outlet by a gas flow path, said flow path causing said gaseous material to alternate between flowing a direction toward and a direction away from said gas outlet; and discharging said gas from said gas outlet into said area to be protected.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; a nozzle stem having an axial bore formed therein; and at least a first innermost partition and a second outer partition located within said housing, said first partition defining an inner gas-receiving chamber into which said nozzle stem extends and into which a gas flowing through said gas inlet and said axial bore is received, said first and second partitions cooperating to define a first annular region therebetween, said first annular region being fluidly connected with said inner gas-receiving chamber by a first passage

located at the distal end of said first partition opposite said gas inlet, said partitions being configured such that gas flowing from said chamber into said first annular region undergoes a 180° change in direction as it flows through said first passage resulting in the gas flowing in said first annular region in an opposite direction to the gas flowing in said inner gas-receiving chamber, said second partition partially defining a second annular region outboard of said second partition, said second annular region being fluidly connected with said first annular region by a second passage located opposite from said first passage, said second annular region being configured such that the gas flows in said second annular region toward said gas outlet in an opposite direction to the gas flowing in said first annular region, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; a plurality of generally cylindrical partitions located within said housing, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber, said innermost partition including a first passage located at the distal end of said innermost partition opposite said gas inlet; and a nozzle stem having an axial bore formed therein, said nozzle stem extending into said inner gas-receiving chamber and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing, said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet and that gas flowing between said gas inlet and said gas outlet makes at least two 180° changes in direction, wherein the gas flowing between said gas inlet and gas outlet undergoes a first 180° change in direction as it flows through said first passage.

In another aspect, there is provided a method of reducing the acoustic energy generated by the discharge of an inert gas from a fire-suppression system comprising: detecting a hazardous condition indicative of a fire or heat-related event within an area to be protected by said suppression system; initiating a flow of said gas from a pressurized gas source toward said area to be protected; directing said flow of gas through a nozzle installed within said protected area having a gas inlet fluidly connected with a gas outlet by a gas flow path, said flow path causing said gaseous material to alternate between flowing a direction

toward and a direction away from said gas outlet, and wherein said flow path causes said gas to undergo at least two 180° changes in direction during passage of said gas through said nozzle; and discharging said gas from said gas outlet into said area to be protected.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; a plurality of generally cylindrical partitions located within said housing, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber; and a nozzle stem having an axial bore formed therein and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, wherein said nozzle stem comprises a fastening element operable to secure at least one of said partitions within said housing, wherein said plurality of partitions are attached to a circular end plate, which is secured to said nozzle stem by said fastening element, said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; a plurality of generally cylindrical partitions located within said housing, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber, wherein said plurality of partitions comprise a plurality of cup-shaped elements having an open end and an opposed closed end, said cup-shaped elements being oriented such that the open end of one cup-shaped element is located adjacent the closed end of at least one other cup-shaped element, said open end of said innermost partition defining a first passage between said innermost partition and one other of said cup-shaped elements; and a nozzle stem having an axial bore formed therein, said nozzle stem extending into said inner gas-receiving chamber and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing, said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet, wherein the gas flowing between said gas inlet and gas outlet undergoes a 180° change in direction as it flows through said first passage.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; a plurality of generally cylindrical partitions located within said housing, said plurality of partitions including an outermost partition within which the others of said plurality of partitions are nested, said plurality of partitions having progressively increasing diameters as said outermost partition is approached, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber, said innermost partition including a first passage located at the distal end of said innermost partition opposite said gas inlet; and a nozzle stem having an axial bore formed therein, said nozzle stem extending into said inner gas-receiving chamber and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing, said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet and that gas flowing between said gas inlet and said gas outlet undergoes a 180° change in direction as it flows through said first passage.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; and at least a first innermost partition and a second outer partition located within said housing, said first partition defining an inner gas-receiving chamber into which a gas flowing through said gas inlet is received, said first and second partitions cooperating to define a first annular region therebetween, said first annular region being fluidly connected with said inner gas-receiving chamber by a first passage located at the distal end of said first partition, said partitions being configured such that the gas flows in said first annular region in an opposite direction to the gas flowing in said inner gas-receiving chamber, said second partition partially defining a second annular region outboard of said second partition, said second annular region being fluidly connected with said first annular region by a second passage located opposite from said first passage, said second annular region being configured such that the gas flows in said second annular region toward said gas outlet in an opposite direction to the gas flowing in said first annular region, said nozzle further comprising third and fourth partitions outboard of said first and second partitions, said second and third partitions cooperatively defining said second annular region, said third and fourth

partitions cooperatively defining a third annular region, said fourth partition and said nozzle housing cooperatively defining a fourth annular region.

In another aspect, there is provided a nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising: a nozzle housing having a gas inlet and a gas outlet; a nozzle stem having an axial bore formed therein; and at least a first innermost partition and a second outer partition located within said housing, said first partition defining an inner gas-receiving chamber into which said nozzle stem extends and into which a gas flowing through said gas inlet and said axial bore is subsequently received, wherein said first and second partitions are substantially cylindrical and are attached to a circular end plate, said first and second partitions cooperating to define a first annular region therebetween, said first annular region being fluidly connected with said inner gas-receiving chamber by a first passage located at the distal end of said first partition opposite said gas inlet, said partitions being configured such that the gas flows in said first annular region in an opposite direction to the gas flowing in said inner gas-receiving chamber, said second partition partially defining a second annular region outboard of said second partition, said second annular region being fluidly connected with said first annular region by a second passage located opposite from said first passage, said second annular region being configured such that the gas flows in said second annular region toward said gas outlet in an opposite direction to the gas flowing in said first annular region, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic representation of a hazzard suppression system, such as an inert gas suppression system;

Fig. 2 is a perspective view of a nozzle assembly according to one embodiment of the present invention;

Fig. 3 is an exploded view of the nozzle assembly of Fig. 2;

Fig. 4 is a cross-sectional view of the nozzle assembly of Fig. 2 also showing the gas flow path through the nozzle;

Fig. 5 is a perspective view of a nozzle assembly according to another embodiment of the present invention;

Fig. 6 is an exploded view of the nozzle assembly of Fig. 5;

Fig. 7 is a cross-sectional view of the nozzle assembly of Fig. 5 showing the gas flow path through the nozzle;

33. The method according to claim 32, wherein said plurality partitions are concentric.

34. A nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising:

a nozzle housing having a gas inlet and a gas outlet;

a nozzle stem having an axial bore formed therein; and

at least a first innermost partition and a second outer partition located within said housing, said first partition defining an inner gas-receiving chamber into which said nozzle stem extends and into which a gas flowing through said gas inlet and said axial bore is received,

said first and second partitions cooperating to define a first annular region therebetween, said first annular region being fluidly connected with said inner gas-receiving chamber by a first passage located at the distal end of said first partition opposite said gas inlet,

said partitions being configured such that gas flowing from said chamber into said first annular region undergoes a 180° change in direction as it flows through said first passage resulting in the gas flowing in said first annular region in an opposite direction to the gas flowing in said inner gas-receiving chamber,

said second partition partially defining a second annular region outboard of said second partition, said second annular region being fluidly connected with said first annular region by a second passage located opposite from said first passage, said second annular region being configured such that the gas flows in said second annular region toward said gas outlet in an opposite direction to the gas flowing in said first annular region,

said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing.

35. A nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising:

a nozzle housing having a gas inlet and a gas outlet;

a plurality of generally cylindrical partitions located within said housing, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber, said innermost partition including a first passage located at the distal end of said innermost partition opposite said gas inlet; and

a nozzle stem having an axial bore formed therein, said nozzle stem extending into said inner gas-receiving chamber and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing,

said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet and that gas flowing between said gas inlet and said gas outlet makes at least two 180° changes in direction, wherein the gas flowing between said gas inlet and gas outlet undergoes a first 180° change in direction as it flows through said first passage.

36. A method of reducing the acoustic energy generated by the discharge of an inert gas from a fire-suppression system comprising:

detecting a hazardous condition indicative of a fire or heat-related event within an area to be protected by said suppression system;

initiating a flow of said gas from a pressurized gas source toward said area to be protected;

directing said flow of gas through a nozzle installed within said protected area having a gas inlet fluidly connected with a gas outlet by a gas flow path, said flow path causing said gaseous material to alternate between flowing a direction toward and a direction away from said gas outlet, and wherein said flow path causes said gas to undergo at least two 180° changes in direction during passage of said gas through said nozzle; and

discharging said gas from said gas outlet into said area to be protected.

37. A nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising:

a nozzle housing having a gas inlet and a gas outlet;

a plurality of generally cylindrical partitions located within said housing, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber; and

a nozzle stem having an axial bore formed therein and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, wherein said nozzle stem comprises a fastening element operable to secure at least one of said partitions within said housing,

wherein said plurality of partitions are attached to a circular end plate, which is secured to said nozzle stem by said fastening element,

said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet.

38. A nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising:

a nozzle housing having a gas inlet and a gas outlet;

a plurality of generally cylindrical partitions located within said housing, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber,

wherein said plurality of partitions comprise a plurality of cup-shaped elements having an open end and an opposed closed end, said cup-shaped elements being oriented such that the open end of one cup-shaped element is located adjacent the closed end of at least one other cup-shaped element, said open end of said innermost partition defining a first passage between said innermost partition and one other of said cup-shaped elements; and

a nozzle stem having an axial bore formed therein, said nozzle stem extending into said inner gas-receiving chamber and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing,

said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet, wherein the gas

flowing between said gas inlet and gas outlet undergoes a 180° change in direction as it flows through said first passage.

39. A nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising:

a nozzle housing having a gas inlet and a gas outlet;

a plurality of generally cylindrical partitions located within said housing, said plurality of partitions including an outermost partition within which the others of said plurality of partitions are nested, said plurality of partitions having progressively increasing diameters as said outermost partition is approached, said partitions cooperating to define a flow path for the gas as it flows between said gas inlet and said gas outlet, said plurality of partitions including an innermost partition defining an inner gas-receiving chamber, said innermost partition including a first passage located at the distal end of said innermost partition opposite said gas inlet; and

a nozzle stem having an axial bore formed therein, said nozzle stem extending into said inner gas-receiving chamber and operable to conduct gas through said gas inlet into said inner gas-receiving chamber, said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing,

said flow path being configured such that gas flowing therein is forced to alternate between flowing a direction toward and a direction away from said gas outlet and that gas flowing between said gas inlet and said gas outlet undergoes a 180° change in direction as it flows through said first passage.

40. A nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising:

a nozzle housing having a gas inlet and a gas outlet; and

at least a first innermost partition and a second outer partition located within said housing, said first partition defining an inner gas-receiving chamber into which a gas flowing through said gas inlet is received,

said first and second partitions cooperating to define a first annular region therebetween, said first annular region being fluidly connected with said inner gas-receiving chamber by a first passage located at the distal end of said first partition,

said partitions being configured such that the gas flows in said first annular region in an opposite direction to the gas flowing in said inner gas-receiving chamber,

said second partition partially defining a second annular region outboard of said second partition, said second annular region being fluidly connected with said first annular region by a second passage located opposite from said first passage, said second annular region being configured such that the gas flows in said second annular region toward said gas outlet in an opposite direction to the gas flowing in said first annular region,

said nozzle further comprising third and fourth partitions outboard of said first and second partitions, said second and third partitions cooperatively defining said second annular region, said third and fourth partitions cooperatively defining a third annular region, said fourth partition and said nozzle housing cooperatively defining a fourth annular region.

41. A nozzle for introducing a gas into an area to be protected by an inert gas hazard-suppression system comprising:

a nozzle housing having a gas inlet and a gas outlet;

a nozzle stem having an axial bore formed therein; and

at least a first innermost partition and a second outer partition located within said housing, said first partition defining an inner gas-receiving chamber into which said nozzle stem extends and into which a gas flowing through said gas inlet and said axial bore is subsequently received, wherein said first and second partitions are substantially cylindrical and are attached to a circular end plate,

said first and second partitions cooperating to define a first annular region therebetween, said first annular region being fluidly connected with said inner gas-receiving chamber by a first passage located at the distal end of said first partition opposite said gas inlet,

said partitions being configured such that the gas flows in said first annular region in an opposite direction to the gas flowing in said inner gas-receiving chamber,

said second partition partially defining a second annular region outboard of said second partition, said second annular region being fluidly connected with said first annular region by a second passage located opposite from said first passage, said second annular region being configured such that the gas flows in said second annular region toward said gas outlet in an opposite direction to the gas flowing in said first annular region,

said nozzle stem comprising a fastening element operable to secure at least one of said partitions within said housing.