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(54) **A FIRE EXTINGUISHING FORMULATION WITH IMPROVED FOAMING**

(57) The current invention relates to a fluorine-free fire extinguishing formulation comprising: a fire retardant agent chosen from the group of ammonium phosphates, phosphate esters, halogenated phosphates, phosphonates, red phosphorus, calcium silicate, sodium silicate, aluminium trihydroxide, magnesium dihydroxide, melamine, polybrominated diphenyl ethers (PBDE), tetrabromobisphenol A (TBBPA), hexabromocyclododecane (HBCD), brominated phenol, or combinations thereof; a mixture of at least two different amphoteric surfactants;

a mixture of at least two different anionic surfactants; an organic solvent; and a hydrophilic solvent, wherein said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,10 and 5,00 wt.% and of between 0,10 and 5,00 wt.% based on the total weight of the fire extinguishing formulation.

A second and third aspect of the invention respectively concern the use of the fire extinguishing formulation, and a fire extinguisher comprising said formulation.

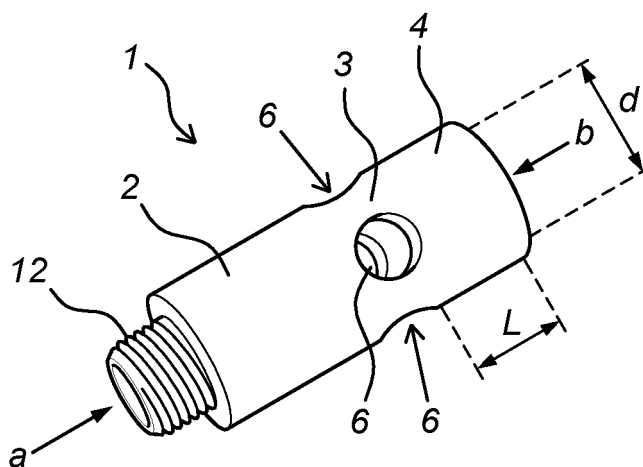


Fig. 1

Description**FIELD OF THE INVENTION**

5 **[0001]** The present invention pertains to a fire extinguishing formulation. In particular, the invention relates to a fire extinguishing formulation with improved foaming characteristics.

BACKGROUND

10 **[0002]** Fire extinguishing compositions generally contain mixtures of surfactants that act as foaming agents, together with solvents and other additives that provide the desired mechanical and chemical properties to the foam. There is a general desire to improve the foaming characteristics of known fire extinguishing compositions, in order to obtain a fire extinguishing process that is faster, more efficient, and in particular, specifically tailored towards a certain fire class.

15 **[0003]** One way of improving the foaming characteristics of fire extinguishing compositions, is by altering the composition itself. For this purpose, fluorinated surfactants have long been used to improve foaming properties, however they have recently come under scrutiny in the light of environmental safety. Fire extinguishing compositions comprising fluorinated surfactants are described in e.g. EP 0 208 682.

[0004] Other examples of fire extinguishing compositions comprising fluorinated surfactants can be found in US 4 090 967, CN 106 730 567 and CN 1 111 686 397.

20 **[0005]** Alternatively, high molecular weight polymeric additives such as acrylic polymers and polysaccharide gums have been added to fire extinguishing compositions in order to lower the amount of fluorinated surfactants needed, while still obtaining a reasonable foam expansion and stability. Such a composition is described in e.g. EP 2 969 052. The present alternatives however comprise some drawbacks, like increased viscosity and thus a difficult application of the fire extinguishing foam. Furthermore, often these fire extinguishing foams are not equally applicable for extinguishing class A and class B fires.

25 **[0006]** Consequently, there remains a need in the art for a fire extinguishing formulation which further improves foaming characteristics, i.e. yields a better foam expansion, improved foam stability, and is suitable for both extinguishing class A and class B fires.

[0007] The present invention aims to resolve at least some of the problems and disadvantages mentioned above.

SUMMARY OF THE INVENTION

[0008] The present invention and embodiments thereof serve to provide a solution to one or more of above-mentioned disadvantages. To this end, the present invention relates to a fire extinguishing formulation according to claim 1.

35 **[0009]** Preferred embodiments of the fire extinguishing formulation are described in claims 2 to 11.

[0010] In a second aspect, the present invention relates to the use of the fire extinguishing formulation for extinguishing class A or class B fires according to claim 12.

[0011] Preferred embodiments of said use are described in claims 13 and 14.

40 **[0012]** The present invention furthermore relates to a third aspect, which concerns a fire extinguisher according to claim 15.

FIGURES

45 **[0013]**

Figure 1 shows a perspective view of an embodiment of a fire extinguishing nozzle according to the present invention, which nozzle comprises a single, indivisible body.

50 **Figure 2** shows a perspective view of an embodiment of a fire extinguishing nozzle according to the present invention, which nozzle comprises a single, indivisible body.

Figure 3a shows a perspective view of an embodiment of an assembled fire extinguishing nozzle according to the present invention, which nozzle comprises three separate and/or detachable parts.

55 **Figure 3b** shows a perspective view of an embodiment of a disassembled fire extinguishing nozzle according to the present invention, which nozzle comprises three separate and/or detachable parts.

Figure 4a shows a perspective view of an embodiment of an assembled fire extinguishing nozzle for using the

formulation according to the present invention for extinguishing class A and B fires, which nozzle comprises three separate and/or detachable parts.

Figure 4b shows a perspective view of an embodiment of a disassembled fire extinguishing nozzle for using the formulation according to the present invention for extinguishing class A and B fires, which nozzle comprises three separate and/or detachable parts.

Figure 5 shows a perspective view of an embodiment of a ventilation chamber for using the formulation according to the present invention for extinguishing class A and B fires.

Figure 6 shows a perspective view of an embodiment of a ventilation chamber and a foaming chamber for using the formulation according to the present invention for extinguishing class A and B fires, which ventilation and foaming chamber form a single, indivisible body.

Figure 7 shows a perspective view and a cross-sectional inlet view of an embodiment of a mixing chamber for using the formulation according to the present invention for extinguishing class A and B fires.

Figure 8 shows a sectional representation according to a central, axial axis of an embodiment of a ventilation chamber for using the formulation according to the present invention for extinguishing class A and B fires.

DETAILED DESCRIPTION OF THE INVENTION

[0014] The present invention concerns a fire extinguishing composition with improved foaming characteristics.

[0015] Unless otherwise defined, all terms used in disclosing the invention, including technical and scientific terms, have the meaning as commonly understood by one of ordinary skill in the art to which this invention belongs. By means of further guidance, term definitions are included to better appreciate the teaching of the present invention.

[0016] As used herein, the following terms have the following meanings:

"A", "an", and "the" as used herein refers to both singular and plural referents unless the context clearly dictates otherwise. By way of example, "a compartment" refers to one or more than one compartment.

[0017] "Comprise", "comprising", and "comprises" and "comprised of" as used herein are synonymous with "include", "including", "includes" or "contain", "containing", "contains" and are inclusive or open-ended terms that specifies the presence of what follows e.g. component and do not exclude or preclude the presence of additional, non-recited components, features, element, members, steps, known in the art or disclosed therein.

[0018] The recitation of numerical ranges by endpoints includes all numbers and fractions subsumed within that range, as well as the recited endpoints.

[0019] The expression "% by weight", "weight percent", "% wt" or "wt. %", here and throughout the description unless otherwise defined, refers to the relative weight of the respective component based on the overall weight of the formulation.

[0020] In a first aspect, the invention concerns a fluorine-free fire extinguishing formulation comprising:

- a fire retardant agent chosen from the group of ammonium phosphates, phosphate esters, halogenated phosphates, phosphonates, red phosphorus, calcium silicate, sodium silicate, aluminium trihydroxide, magnesium dihydroxide, melamine, polybrominated diphenyl ethers (PBDE), tetrabromobisphenol A (TBBPA), hexabromocyclododecane (HBCD), brominated phenol, or combinations thereof,
- a mixture of at least two different amphoteric surfactants,
- a mixture of at least two different anionic surfactants,
- an organic solvent, and
- a water.

[0021] Herein, said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,10 and 5,00 wt.% and of between 0,10 and 5,00 wt.% based on the total weight of the fire extinguishing formulation.

[0022] The fire extinguishing composition is fluorine-free and does not contain any fluorinated compounds. Non-fluorinated fire extinguishing compositions are preferred over fluorinated compositions, as fluorinated compositions have recently come under scrutiny in the light of environmental safety. However, fire extinguishing compositions generally contain fluorinated compounds, e.g. as surfactants, that act as foaming agents in order to provide the desired mechanical and chemical properties to the foam. The fire extinguisher as herein described now provides for the formation of a comparable or even better quality foam, using a fluorine-free fire extinguishing composition. The mixture of at least two different amphoteric surfactants and the mixture of at least two different anionic surfactants, does not contain any

fluorinated compounds. However, the fire extinguishing composition shows good foaming characteristics and is suitable in fire extinguishing compositions.

[0023] A composition without fluorinated compounds or a fluorine-free composition refers to a composition without molecules comprising a carbon-fluor bond. Polyfluoroalkyl substances (PFASs) are examples of such fluorinated compounds. PFASs are known to persist in the environment and are commonly described as persistent organic pollutants. When combining at least two amphoteric surfactants and two different anionic surfactants, according to the present invention, an easy to apply fire extinguishing formulation is obtained, which spreads quickly over a burning solid or liquid surface, and provides for a large foam volume with good stability.

[0024] The expression "fire retardant agent" refers to a diverse group of chemicals which are intended to prevent or slow down the development of a fire, or to extinguish a fire, by a variety of different physical and chemical methods. Regarding the extinguishment of a fire, fire retardant agents are generally formulated as a dry formulation, or are to be applied as a fire extinguishing foam. Fire retardant agents which are regularly used in fire extinguishing foams are, among others, monoammonium dihydrogen phosphate (MAP), diammonium phosphate (DAP), urea, sodium carbonate, potassium bicarbonate, or potassium chloride. In light of the present invention, fire retardant agents are chosen from the group of ammonium phosphates, phosphate esters, halogenated phosphates, phosphonates, red phosphorus, calcium silicate, sodium silicate, aluminium trihydroxide, magnesium dihydroxide, melamine, polybrominated diphenyl ethers (PBDE), tetrabromobisphenol A (TBBPA), hexabromocyclododecane (HBCD), brominated phenol, or combinations thereof.

[0025] The expression "surfactants" refers to compounds that lower the surface tension (or interfacial tension) between two liquids, between a gas and a liquid, or between a liquid and a solid. Surfactants may as such act as detergents, wetting agents, emulsifiers, foaming agents, or dispersants. Surfactants are usually organic compounds that are amphiphilic, i.e. containing both hydrophobic and hydrophilic groups.

[0026] In light of the present invention, the term "amphoteric surfactant" or "zwitterionic surfactant" refers to surfactants which comprise both cationic and anionic functional groups. The cationic part is based on primary, secondary, or tertiary amines or quaternary ammonium cations. The anionic part is generally of a more variable nature.

[0027] The expression "anionic surfactants" pertains to those surfactants which comprise anionic functional groups at their head, such as sulfates, sulfonates, phosphates, and carboxylates.

[0028] The "cationic surfactants" relate to those surfactants having cationic functional groups, e.g. pH-dependent primary, secondary, or tertiary amines, permanently charged quaternary ammonium salts such as cetrimonium bromide (CTAB), cetylpyridinium chloride (CPC), benzalkonium chloride (BAC), benzethonium chloride (BZT), dimethyldioctadecylammonium chloride, and dioctadecyldimethylammonium bromide (DODAB).

[0029] "Non-ionic surfactants" have covalently bonded oxygen-containing hydrophilic groups, which are bonded to hydrophobic parent structures. The water-solubility of the oxygen groups is the result of hydrogen bonding. Hydrogen bonding decreases with increasing temperature, and the water solubility of non-ionic surfactants therefore decreases with increasing temperature.

[0030] The present invention thus concerns a fire extinguishing formulation comprising both amphoteric and anionic surfactants, i.e. those surfactants comprising anionic functional groups, in particular at least two of each group.

[0031] A "solvent" is a substance that dissolves a solute, resulting in a solution. A solvent is usually a liquid but can also be a solid, a gas, or a supercritical fluid. In light of the present invention, the formulation generally comprises a liquid solvent. Solvents can be broadly classified into two categories: polar and non-polar. Solvents with a dielectric constant of less than 15 are generally considered to be "non-polar solvents", while solvents with a dielectric constant of 15 and higher are considered to be "polar solvents". Heuristically, the dielectric constant of a solvent can be thought of as its ability to reduce the solute's effective internal charge. As a consequence, the dielectric constant of a solvent is an acceptable predictor of the solvent's ability to dissolve common ionic compounds, such as salts.

[0032] The fire extinguishing formulation according to the present invention shows exceptionally high foam expansion upon application, which allows efficient fire extinguishment, especially regarding fire class A and B. The specific combination of at least two amphoteric and at least two anionic surfactants that are non-fluorinated herein supports said high foam expansion without the need for fluorinated compounds, nor for heavy polymeric compounds. As such, the present formulation is easily applied, spreads quickly over a burning solid or liquid surface, and provides for a large foam volume with good stability.

[0033] By preference, said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,25 and 3,50 wt.% and of between 0,25 and 3,50 wt.% based on the total weight of the fire extinguishing formulation.

[0034] By preference, said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,25 and 2,50 wt.% and of between 0,25 and 2,50 wt.% based on the total weight of the fire extinguishing formulation.

[0035] The formulation according to the present invention shows the herein described effects, i.e. large foam expansion, good foam stability, easy application and quick spreading of the foam, even for considerably low surfactant concentrations,

as provided for within the described ranges. This allows for a fire extinguishing composition wherein the present fire retardant agents are allowed to express high fire extinguishing activity. As such, less foam is needed to obtain the intended result of extinguishing class A and B fires, even for larger burning areas.

[0036] More by preference, said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,25 and 2,00 wt.% and of between 0,25 and 2,00 wt.%, of between 0,25 and 1,90 wt.% and of between 0,30 and 2,00 wt.%, of between 0,25 and 1,80 wt.% and of between 0,40 and 2,00 wt.%, of between 0,25 and 1,70 wt.% and of between 0,50 and 2,00 wt.%, or of between 0,50 and 1,60 wt.% and of between 0,50 and 2,00 wt.% based on the total weight of the fire extinguishing formulation. Even more by preference, said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,25 and 1,50 wt.% and of between 0,50 and 2,00 wt.% based on the total weight of the fire extinguishing formulation.

[0037] According to a further or another embodiment, said mixture of amphoteric surfactants comprises at least three different amphoteric surfactants, and said mixture of anionic surfactants comprises at least three different anionic surfactants. By further diversifying the amphoteric and anionic surfactants present in the formulation, foam expansion, as well as the general efficacy of the formulation in extinguishing class A and B fires, is further improved.

[0038] In some embodiments, said mixture of amphoteric surfactants comprises at least four, five, or six different amphoteric surfactants. In some embodiments, said mixture of anionic surfactants comprises at least four, five or six different anionic surfactants. Further diversification of the amphoteric and anionic surfactants further improves the described effects.

[0039] Said organic solvent, according to a further or another embodiment, has a concentration of between 2,50 and 10,00 wt.% based on the total weight of the fire extinguishing formulation. The presence of the organic solvent in the herein defined ranges allows for a formulation which allows the formation of a high foam volume and wherein the present fire retardant agents are homogeneously distributed. As such, the general efficacy of the fire extinguishing composition is further improved.

[0040] By preference, said organic solvent is present in a concentration of between 3,00 and 9,00 wt.%, of between 3,00 and 8,00 wt.%, of between 3,50 and 7,50 wt.%, of between 4,00 and 7,00 wt.%, or of between 4,00 and 6,50 wt.% based on the total weight of the fire extinguishing formulation. More by preference, said organic solvent is present in a concentration of between 4,00 and 6,00 wt.% based on the total weight of the fire extinguishing formulation.

[0041] According to a further or another embodiment, the fire extinguishing formulation comprises a foam stabilizer, said foam stabilizer is present in a concentration of between 0,10 and 5,00 wt.% based on the total weight of the fire extinguishing formulation.

[0042] A "foam stabilizer" herein refers to those compounds known in the art to further improve foam stability, i.e. which allows the foam to stay intact longer and thus prolong the fire extinguishing activity of the composition. The present invention, in particular the selective combination of at least two amphoteric and at least two anionic surfactants, allows a relatively low concentration of a foam stabilizer in the fire extinguishing composition within the ranges as defined herein.

[0043] In an embodiment, said foam stabilizers are chosen from the group of DEG: diethylene glycol; TEG: triethylene glycol; MPG: monopropylene glycol; DPG: dipropylene glycol; TPG: tripropylene glycol; PEG - 200; BDG butyl di glycol or mixtures thereof.

[0044] By preference, said foam stabilizer is present in a concentration of between 0,10 and 4,50 wt.%, of between 0,10 and 4,00 wt.%, of between 0,10 and 3,50 wt.%, or of between 0,10 and 3,00 wt.% based on the total weight of the fire extinguishing formulation. More by preference, said foam stabilizer is present in a concentration of between 0,10 and 2,50 wt.%, of between 0,10 and 2,40 wt.%, of between 0,20 and 2,30 wt.%, of between 0,30 and 2,20 wt.%, of between 0,40 and 2,10 wt.%, or of between 0,50 and 2,00 wt.% based on the total weight of the fire extinguishing formulation.

[0045] According to a further or another embodiment, the fire extinguishing formulation comprises a heat stabilizer, said heat stabilizer is present in a concentration of between 0,50 and 10,00 wt.% based on the total weight of the fire extinguishing formulation. It is the purpose of the heat stabilizer to further improve stability of the fire extinguishing foam upon exposure to extreme heat. The present invention, in particular the selective combination of at least two amphoteric and at least two anionic surfactants, allows a relatively low concentration of a heat stabilizer in the fire extinguishing composition within the ranges as defined herein.

[0046] The fire extinguishing formulation according to some embodiments comprises the fire retardant agent in a concentration of between 1,00 to 15,00 wt.% based on the total weight of the fire extinguishing formulation. Within the specified ranges, the fire extinguishing composition allows extinguishing class A and B fires in an exceptionally efficient manner.

[0047] By preference, the fire retardant agent is present in a concentration of between 1,00 to 14,50 wt.%, of between 1,00 to 14,00 wt.%, of between 1,00 to 13,50 wt.%, of between 1,00 to 13,00 wt.%, of between 1,00 to 12,50 wt.%, of between 1,00 to 12,0 wt.%, of between 1,00 to 11,50 wt.%, or of between 1,00 to 11,00 wt.% based on the total weight of the fire extinguishing formulation. More by preference, the fire retardant agent is present in a concentration of between 1,00 to 10,90 wt.%, of between 1,00 to 10,80 wt.%, of between 1,00 to 10,70 wt.%, of between 1,00 to 10,60 wt.%, or

of between 1,00 to 10,50 wt.% based on the total weight of the fire extinguishing formulation. Even more by preference, the fire retardant agent is present in a concentration of between 1,10 to 10,40 wt.%, of between 1,20 to 10,30 wt.%, of between 1,30 to 10,20 wt.%, of between 1,40 to 10,10 wt.%, or of between 1,50 to 10,00 wt.% based on the total weight of the fire extinguishing formulation.

5 **[0048]** In a preferred embodiment, the fire extinguishing formulation comprises:

- between 1,50 and 10,00 wt.% of fire retardant agent;
- between 0,25 and 1,50 wt.% of amphoteric surfactants;
- between 0,50 and 2,00 wt.% of anionic surfactants;
- 10 - between 0,50 and 2,00 wt.% of foam stabilizer;
- between 0,50 and 10,00 wt.% of heat stabilizer;
- between 2,50 and 10,00 wt.% of organic solvent; and
- between 50,00 and 95,00 wt.% of water.

15 **[0049]** The fire extinguishing formulation thus allows efficient extinguishment of class A and B fires, wherein the formulation shows exceptional foam expansion, resulting in a foam with large volume, high stability, which foam easily spreads and lasts considerably long.

[0050] According to some embodiments, said amphoteric surfactants are chosen from the group of betaines, sultaines, alkylamphoacetates, amphodiacetates, alkylamphopropionates, alkyliminodipropionates, amphodipropionates, aliphatic quaternary ammonium compounds, aliphatic quaternary phosphonium compounds, aliphatic quaternary sulfonium compounds, derivatives or combinations thereof.

[0051] According to some embodiments, said amphoteric surfactants are chosen from the group of betaines, sultaines, alkylamphoacetates, amphodiacetates, alkylamphopropionates, alkyliminodipropionates, amphodipropionates, or combinations thereof.

25 **[0052]** In some embodiments, said betaines are chosen from the group of betaine, alkyl betaine, alkylamido betaine, sulfobetaine, or combinations thereof.

[0053] In some embodiments, said alkyl betaine is chosen from the group of coco dimethyl carboxymethyl betaine, cocoamidopropyl betaine, cocobetaine, lauryl amidopropyl betaine, oleyl betaine, lauryl dimethyl carboxymethyl betaine, lauryl dimethyl alpha-carboxyethyl betaine, cetyl dimethyl carboxymethyl betaine, lauryl bis-(2-hydroxyethyl) carboxymethyl betaine, stearyl bis-(2-hydroxypropyl) carboxymethyl betaine, oleyl dimethyl gamma-carboxypropyl betaine, lauryl bis-(2-hydroxypropyl)alpha-carboxyethyl betaine, or combinations thereof.

[0054] In some embodiments, said alkyl amidopropyl betaines are chosen from the group of cocamidopropyl betaine, lauramidopropyl betaine, oleamidopropyl betaine, erucic amidopropyl betaine, or combinations thereof.

35 **[0055]** In some embodiments, said sulfobetaines are chosen from the group of coco dimethyl sulfopropyl betaine, stearyl dimethyl sulfopropyl betaine, lauryl dimethyl sulfoethyl betaine, lauryl bis-(2-hydroxyethyl) sulfopropyl betaine, or combinations thereof.

[0056] According to a further or another embodiment, said amphoteric surfactants are chosen from the group of aliphatic quaternary ammonium compounds, aliphatic quaternary phosphonium compounds, aliphatic quaternary sulfonium compounds, derivatives or combinations thereof. By preference, said amphoteric surfactants are chosen from the group of 4-[N,N-di(2-hydroxyethyl)-N-octadecylammonio]-butane-1-carboxylate; 5-[S-3-hydroxypropyl-5-hexadecylsulfonio]-3-hydroxypentane-1-sulfate; 3-[P,P-diethyl-P-3,6,9-trioxatetradecylphosphonio]-2-hydroxypropane-1-phosphate; 3-[N,N-dipropyl-N-3-dodecoxy-2-hydroxypropylammonio]-propane-1-phosphonate; 3-(N,N-dimethyl-N-hexadecylammino)propane-1-sulfonate; 3-(N,N-dimethyl-N-hexadecylammonio)-2-hydroxypropane-1-sulfonate; 4-[N,N-di(2-hydroxyethyl)-N-(2-hydroxydodecyl)ammonio]-butane-1-carboxylate; 3-[S-ethyl-S-(3-dodecoxy-2-hydroxypropyl)sulfonio]-propane-1-phosphate; 3-[P,P-dimethyl-P-dodecylphosphonic]-propane-1-phosphonate; and 5-[N,N-di(3-hydroxypropyl)-N-hexadecylammonio]-2-hydroxypentane-1-sulfate, or combinations thereof.

[0057] In a preferred embodiment, said amphoteric surfactants are chosen from the group of alkyl betaine, betaine derivatives of alkyl polyglucosides, or combinations thereof.

50 **[0058]** According to some embodiments, said anionic surfactants are chosen from the group of alkyl sulfates, alkyl ether sulfates, alkyl ether sulfonates, sulfate esters of an alkylphenoxy polyoxyethylene ethanol, alcohol ammonium sulfates, alpha-olefin sulfonates, beta alkoxy alkane sulfonates, alkyl lauryl sulfonates, alkyl monoglyceride sulfates, alkyl monoglyceride sulfonates, alkyl carbonates, alkyl ether carboxylates, fatty acids, fatty alcohol sulfates, sulfosuccinates, sarcosinates, octoxynol or nonoxynol phosphates, taurates, fatty taurides, fatty acid amide polyoxyethylenes, isethionates, anionic derivatives of alkyl polyglucosides, or combinations thereof.

55 **[0059]** According to some embodiments, said anionic surfactants are chosen from the group of C8-C18 alkyl sulfates, C8-C18 fatty acid salts, C8-C18 alkyl ether sulfates having one or two moles of ethoxylation, C8-C18 alkamine oxides, C8-C18 alkoyl sarcosinates, C8-C18 sulfoacetates, C8-C18 sulfosuccinates, C8-C18 alkyl diphenyl oxide disulfonates, C8-C18 alkyl carbonates, C8-C18 alpha-olefin sulfonates, methyl ester sulfonates, or combinations thereof.

[0060] By preference, said anionic surfactants are chosen from the group of lauryl sulfates, octyl sulfates, 2-ethylhexyl sulfates, lauramine oxide, decyl sulfates, tridecyl sulfates, triethanol ammonium alkyl sulfate, cocoates, lauroyl sarcosinates, lauryl sulfosuccinates, linear C10 diphenyl oxide disulfonates, lauryl sulfosuccinates, lauryl ether sulfates, myristyl sulfates, oleates, stearates, tallates, ricinoleates, cetyl sulfates, or combinations thereof.

[0061] In some embodiments, said anionic surfactants are chosen from the group of alkyl sulfonates, alkylaryl sulfonates, alkylated diphenyl oxide disulfonates, alkylated naphthalene sulfonates, isethionates, alkylaryl sulfonic acids, secondary alkane sulfonates, alkoxylate carboxylates, sarcosinate, taurate, acyl amino acids, alkanolic esters, phosphate esters, sulfuric acid esters, or combinations thereof.

[0062] In some embodiments, said anionic surfactants are chosen from the group of sodium lauryl glucoside carboxylate, disodium coco-glucoside citrate, sodium coco-glucoside tartrate, disodium coco-glucoside sulfosuccinate; sodium cocoglucosides hydroxypropylsulfonate, sodium decylglucosides hydroxypropylsulfonate, sodium laurylglucosides hydroxypropylsulfonate; sodium hydroxypropylsulfonate cocoglucoside crosspolymer, sodium hydroxypropylsulfonate decylglucoside crosspolymer, sodium hydroxypropylsulfonate laurylglucoside crosspolymer.

[0063] In an embodiment, said anionic surfactants are chosen from the group of alkyl sulfonates, anionic derivatives of alkyl polyglucosides, sulfate esters, or combinations thereof.

[0064] Said organic solvent, in some embodiments of the present invention, is chosen from the group of diols, glycols, glycol ethers, or combinations thereof. By preference, said organic solvent is chosen from the group of ethylene glycol, propylene glycol, butyl-di-glycol, dipropylene glycol n-propyl ether, dipropylene glycol n-butyl ether, propylene glycol n-butyl ether, propylene glycol, n-propyl ether, tripropylene glycol n-butyl ether, propylene glycol phenyl ether, dipropylene glycol phenyl ether, dipropylene glycol dimethyl ether, propylene glycol methyl ether, propylene glycol methyl ether acetate, dipropylene glycol methyl ether, dipropylene glycol methyl ether acetate, tripropylene glycol methyl ether, ethylene glycol hexyl ether, diethylene glycol hexyl ether, ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol monopropyl ether, ethylene glycol monoisopropyl ether, ethylene glycol, monobutyl ether, ethylene glycol monobenzyl ether, diethylene glycol phenyl ether, ethylene glycol phenyl ether, poly(oxy-1,2-ethanediyl), alpha-phenyl-omega-hydroxy, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol n-butyl ether, ethylene glycol n-butyl ether, dipropylene glycol methyl ether, or combinations thereof.

[0065] According to some embodiments said heat stabilizer is chosen from the group of ammonium phosphate, ester phosphate, sodium citrate, sucrose, maltose, dextrose, sodium biocarbonate, sodium carbonate, potassium carbonate, potassium biocarbonate, sodium sulfate, sodium orthophosphate, or combinations thereof.

[0066] In an embodiment, said heat stabilizer is chosen from the group of sucrose, maltose, dextrose, sodium biocarbonate, sodium carbonate, potassium carbonate, potassium biocarbonate, or combinations thereof.

[0067] In a preferred embodiment, the fire extinguishing formulation comprises:

- between 1,50 and 10,00 wt.% of monoammonium dihydrogen phosphate (MAP), diammonium phosphate (DAP), urea, or combinations thereof;
- between 0,25 and 1,50 wt.% of alkyl betaines, betaine derivatives of alkyl polyglucosides, or combinations thereof;
- between 0,50 and 2,00 wt.% of alkyl sulfonates, anionic derivatives of alkyl polyglucosides, sulfate esters, or combinations thereof;
- between 3,00 and 12,00 wt.% of diethylene glycol, triethylene glycol, propylene glycol, dipropylene glycol, tripropylene glycol, polyethylene glycol, butyl di glycol, or mixtures thereof;
- between 0,50 and 10,00 wt.% of sucrose, maltose, dextrose, sodium biocarbonate, sodium carbonate, potassium carbonate, potassium biocarbonate, or combinations thereof;
- between 50,00 and 95,00 wt.% of water.

[0068] A second aspect of the present invention relates to the use of the fire extinguishing formulation according to any of the described embodiments for extinguishing class A or class B fires.

[0069] Regarding the terminology "fire class", according to EN 2 there are six classes of fire. "Fire class A" relates to fires in combustible solids, mainly solids of organic nature such as coal, wood, paper, and fabrics. "Class B fires" relate to fires in flammable liquids, such as gasoline, petroleum, tars, oils, oil-based paints and solvents. "Class C fires" indicate fires in flammable gases, like hydrogen, propane, butane or methane. "Class D fires" are specifically directed towards combustible metals, especially alkali metals such as lithium, sodium and potassium, alkaline earth metals such as magnesium, and group 4 elements such as titanium and zirconium. "Class F fires" relate to fires in cooking oils and fats, e.g. kitchen fires.

[0070] By preference, extinguishing class A or class B fires is performed by means of a fire extinguisher comprising said fire extinguishing formulation according to the first aspect of the invention. Use of the fire extinguishing formulation thus results in the formation of a high-volume fire extinguishing foam with high activity, and thus allows the efficient extinguishing of both class A and B fires.

[0071] As described herein, a "fire extinguisher" is an active fire protection device used to extinguish or control small

or medium-sized fires, often in emergency situations. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing a fire extinguishing composition which can be discharged in order to extinguish a fire.

[0072] More by preference, said fire extinguisher comprises a fire extinguishing nozzle, said nozzle comprising a mixing chamber, a ventilation chamber and a foaming chamber, wherein:

- said ventilation chamber is coupled to said mixing chamber, and comprises a first hollow cylindrical body comprising at least three air inlet holes, said air inlet holes are arranged on the circumference of, and are directed into the first hollow cylindrical body;
- said foaming chamber comprises a second hollow cylindrical body having an axial length (L) and an inner diameter (d), which foaming chamber is coupled to said ventilation chamber; and
- said ventilation chamber and/or said foaming chamber comprise a mesh, wherein said mesh is oriented in the radial plane of the inner cross-section of the ventilation chamber and/or foaming chamber;

and wherein the ratio of the axial length over the inner diameter (L:d) of the foaming chamber is comprised between 4:5 and 9:5 for extinguishing class A fires, or between 6:1 and 10:1 for extinguishing class B fires.

[0073] The nozzle as herein described comprises a mixing chamber, a ventilation chamber and a foaming chamber, wherein the wordings "mixing", "ventilation" and "foaming" specifically indicate the function said chambers perform. As such, they respectively function to (pre)mix a fire extinguishing composition in the nozzle, to allow ventilation and/or aeration of the fire extinguishing composition, and to optimize the process of foaming, i.e. producing a fire extinguishing foam from the liquid fire extinguishing composition as provided to the mixing chamber.

[0074] The term "mesh" as herein described refers to a barrier made of connected strands of metal, fiber, or other flexible or ductile materials. A mesh can also be referred to as a "screen". Meshes are generally characterized by their "mesh size", particularly their "U.S. Mesh Size", which is defined as the number of openings in one square inch of a mesh. For example, a 36 mesh screen will have 36 openings per one square inch. Through the nature of this expression, the average diameter of the openings is however dependent on the thickness of the connected strands. In light of the present invention, the mesh size is preferably expressed as a micron-value indicating the average diameter of the openings of the mesh. For example, a mesh size of 1000 μm indicates a mesh wherein the average diameter of the openings is 1000 μm .

[0075] The term "axial length" represents the length of a cylindrical body along its rotational axis. Accordingly, the "inner diameter" is measured in the perpendicular plane to the rotational axis and extends along the inside of the hollow cylindrical body.

[0076] Use of the fire extinguishing formulation with the fire extinguisher comprising the nozzle as described herein further improves foaming characteristics, particularly foam expansion of the resulting fire extinguishing foam. The specified use has the advantage of improving the foaming characteristics of a fire extinguishing formulation for fire class A or fire class B situations. Relating to the fire extinguishing nozzle whereby the ratio L:d is comprised between 4:5 and 9:5, it is observed that the discharged fire extinguishing foam is of a less compact nature and is thinner than fire extinguishing foams which are discharged through nozzles as generally known in the art. This is particularly advantageous for class A fires, wherein the fire extinguishing foam needs to be applied on the surface of a burning material, which has to be covered as quickly and completely as possible. Generally, where denser foams exhibit slower spreading of the fire extinguishing foam over a burning object, the fire extinguishing nozzle according to the present invention allows faster spreading of a fire extinguishing foam, thus resulting in the highly efficient and highly fast extinguishing of class A fires. Relating to the fire extinguishing nozzle whereby the ratio L:d is comprised between 6:1 and 10:1, it is observed that the discharged fire extinguishing foam is more compact and thicker than fire extinguishing foams which are discharged through nozzles as generally known in the art. This is particularly advantageous for class B fires, as the fire extinguishing foam is intended to form a substantive layer on top of the burning liquid surface. The resulting compact and thick foam layer is able to better contain the flames in a certain area, and thus prevents the further spreading of the fire. Meanwhile, contact between the burning liquid and ambient air is efficiently reduced and/or eliminated, resulting in the liquid fire being more rapidly extinguished. As a result, it is submitted that the fire extinguishing nozzle as herein described provides in a more efficient and a faster extinguishing of class A or class B fires.

[0077] According to a further or another embodiment, said ratio of the axial length over the inner diameter (L:d) of the foaming chamber is comprised between 4:5 and 8:5 for extinguishing class A fires, or between 7:1 and 9:1 for extinguishing class B fires.

[0078] In some embodiments, said ratio of the axial length over the inner diameter (L:d) of the foaming chamber is comprised between 4:5 and 9:5, preferably between 4:5 and 8:5 for extinguishing class A fires.

[0079] In some embodiments, said ratio of the axial length over the inner diameter (L:d) of the foaming chamber is comprised between 6:1 and 10:1, preferably between 7:1 and 9:1 for extinguishing class B fires.

[0080] According to a further or another embodiment, said mesh has a mesh size of between 700 and 1200 μm . It is submitted that the mesh size impacts various foaming characteristics, such as the discharge time, the discharge flow,

foam expansion, foam bubble size, foam discharge angle etc. The inventors have found that the mesh size range as herein described finds a delicate balance between all of the aforementioned foaming characteristics. In particular, smaller meshes give rise to a foam with a smaller bubble size, which is beneficial for the control of e.g. hydrocarbon fires. However, by using a smaller mesh size the amount of foam expansion is reduced, which is suboptimal regarding the extinguishing of class B fires. On the other hand, using a bigger mesh size increases the amount of foam expansion and improves the foam discharge angle, while the resulting bubble size is suboptimal regarding the extinguishing of class A fires. A mesh size of between 700 and 1200 μm exhibits all of the aforementioned advantages, and allows the nozzle as herein described to further optimize foam characteristics for class A or class B fires.

[0081] By preference, said mesh has a mesh size of between 800 and 1100 μm . More by preference, said mesh has a mesh size of between 900 and 1100 μm , even more by preference between 950 and 1050 μm , between 960 and 1040 μm , between 970 and 1030 μm , between 980 and 1020 μm , or between 990 and 1010 μm .

EXAMPLES

[0082] The invention is further described by the following examples which illustrate the invention, and are not intended to, nor should they be interpreted to, limit the scope of the invention.

Example 1 - fire extinguishing formulation

[0083] Examples of fire extinguishing formulations according to the present invention are shown in tables 1-3 below. It is a particular advantage of the invention that the fire extinguishing formulations show optimal fire extinguishing properties, and yield a fire extinguishing foam with a large foam volume, good spreading, and optimal stability, yielding optimal results for extinguishing both class A and B fires.

Table 1. Formulation A according to the invention		component	concentration (wt.%)
<i><u>fire retardant agents</u></i>			
		diammonium phosphate (DAP)	8,50
<i><u>amphoteric surfactant</u></i>			
		coco dimethyl carboxymethyl betaine	0,75
		lauryl bis-(2-hydroxyethyl) carboxymethyl betaine	0,75
<i><u>anionic surfactant</u></i>			
		triethanol ammonium alkyl sulfate	1,25
		sodium hydroxypropylsulfonate laurylglucoside crosspolymer	1,25
<i><u>foam stabilizer</u></i>			
		polyethylene glycol	1,00
<i><u>heat stabilizer</u></i>			
		sucrose	5,00
<i><u>organic solvent</u></i>			
		ethylene glycol	3,00
		water	78,50

Table 2. Formulation B according to the invention		component	concentration (wt.%)
<i><u>fire retardant agents</u></i>			
		diammonium phosphate (DAP)	5,00
		monoammonium dihydrogen phosphate (MAP)	2,00
<i><u>amphoteric surfactant</u></i>			
		lauryl amidopropyl betaine	0,50
		oleyl betaine	0,60
<i><u>anionic surfactant</u></i>			
		alkylated naphthalene sulfonates	1,10
		sodium cocoglucosides hydroxypropylsulfonate	1,60
<i><u>foam stabilizer</u></i>			

(continued)

Table 2. Formulation B according to the invention	
component	concentration (wt.%)
polypropylene glycol	0,90
<u>organic solvent</u>	
dipropylene glycol n-propyl ether	2,50
water	85,8

Table 3. Formulation C according to the invention	
component	concentration (wt.%)
<u>fire retardant agents</u>	
diammonium phosphate (DAP)	5,00
monoammonium dihydrogen phosphate (MAP)	1,50
urea	1,75
<u>amphoteric surfactant</u>	
alkylamphopropionates	0,50
lauryl dimethyl alpha-carboxyethyl betaine	0,50
stearyl bis-(2-hydroxypropyl) carboxymethyl betaine	0,50
<u>anionic surfactant</u>	
alkylated naphthalene sulfonates	1,00
sodium cocoglucosides hydroxypropylsulfonate	1,00
sodium hydroxypropylsulfonate cocoglucoside crosspolymer	0,50
<u>foam stabilizer</u>	
polyethylene glycol	0,90
<u>organic solvent</u>	
propylene glycol	1,50
ethylene glycol	1,50
water	83,85

Example 2 - foaming characteristics

[0084] Foaming characteristics of the formulations A, B and C (cf. Example 1) are compared to a generic fire extinguishing foam X. Nominal discharge time (T), height of the foam (h), volume of the mousse (V) and nominal foam expansion (FE) are given in the table below.

[0085] Formulation X is a conventional fluorinated formulation from the prior art, which is currently sold in the market.

[0086] All formulations were discharged with a fire extinguisher at a pressure of 15 bar, and a volume of 6 L of solution was discharged in order to generate the foams as shown below.

Table 4. Comparison of foaming characteristics of formulations X, A, B and C.

formulation	T (s)	h (cm)	V (L)	FE
X	30	31	75,6	12,5
A	37	36	85,6	13,9
B	35	37	83,3	13,6
C	42	36	81,5	13,8

[0087] It is concluded from the above values that fire extinguishing formulations according to the invention have a substantially longer nominal discharge time, and that the resulting fire extinguishing foam is substantially higher, has a larger foam volume, and has a larger nominal foam expansion. The resulting fire extinguishing foam is especially advantageous for extinguishing fires of classes A and B.

Example 3 - use of fire extinguishing formulation with dedicated nozzle

[0088] Use of the fire extinguishing formulations A, B and C (cf. Example 1) was compared as follows: (i) by means of a fire extinguisher provided with a nozzle as described in some of the embodiments of the invention (as shown in Figures 1-8), (ii) by means of a generic fire extinguishing nozzle. Nominal discharge time (T), height of the foam (h), volume of the mousse (V) and nominal foam expansion (FE) are given in the table below.

[0089] All formulations were discharged with a fire extinguisher at a pressure of 15 bar, and a volume of 6 L of solution was discharged in order to generate the foams as shown below.

Table 5. Comparison of foaming characteristics of formulations A, B and C by using (i) nozzle according to the invention (IN), or (ii) generic nozzle (GN).

formulation	T (s)	h (cm)	V (L)	FE
A / GN	36	36	85,6	13,9
A / IN	57	56	135,2	22,6
B / GN	35	37	83,3	13,6
B / IN	55	56	133,6	22,5
C / GN	42	36	81,5	13,8
C / IN	58	57	137,2	22,6

[0090] It is concluded from the above values that foaming characteristics of the fire extinguishing formulations according to the invention are further enhanced by using them by means of a fire extinguisher provided with a dedicated nozzle according to the invention. Nominal discharge time, foam height, foam volume and nominal foam expansion perform better when using the nozzle according to the invention compared to a generic nozzle as known in the art. The resulting fire extinguishing foam is especially advantageous for extinguishing fires of classes A and B.

DESCRIPTION OF FIGURES

[0091] The following description of the figures of specific embodiments of the invention is merely exemplary in nature and is not intended to limit the present teachings, their application or uses. Throughout the drawings, corresponding reference numerals indicate like or corresponding parts and features. In particular the figures show a fire extinguishing nozzle which is intended for use of the fire extinguishing formulation according to the invention.

[0092] Fig. 1 shows a perspective view of an embodiment of a fire extinguishing nozzle 1 for using the formulation according to the present invention for extinguishing class A and B fires, which nozzle 1 is especially useful for extinguishing class A fires and is to be understood having an inlet a and an outlet b. Herein, the inlet a is to be coupled to a fire extinguisher and the outlet b concerns the passage through which the fire extinguishing composition is discharged. The nozzle 1 comprises a mixing chamber 2, a ventilation chamber 3 and a foaming chamber 4. Notwithstanding the mixing chamber 2, the ventilation chamber 3 and the foaming chamber 4 are formed as a single, indivisible body, the ratio of the axial length over the inner diameter (L:d) of the foaming chamber 4 is unambiguously determined between 4:5 and 9:5. The ventilation chamber 3 comprises four air inlet holes 6, allowing for contact between ambient air and the fire extinguishing composition passing through the nozzle 1. For ease of coupling and/or decoupling the nozzle 1 to a fire extinguisher or fire extinguisher hose, an outer thread 12 is provided at the inlet a. By using the nozzle 1 as herein described, the discharged fire extinguishing foam is of a less compact nature and is thinner than fire extinguishing foams which are discharged through nozzles as generally known in the art. This is particularly advantageous for class A fires, wherein the fire extinguishing foam needs to be applied on the surface of a burning material, which has to be covered as quickly and completely as possible. It is further submitted that the nozzle as herein described further enhances foam expansion of the fire extinguishing composition according to the invention.

[0093] Fig. 2 shows a perspective view of an embodiment of a fire extinguishing nozzle 1 for using the formulation according to the present invention for extinguishing class A and B fires, which nozzle 1 is especially useful for extinguishing class B fires and is to be understood having an inlet a and an outlet b. Herein, the inlet a is to be coupled to a fire extinguisher and the outlet b concerns the passage through which the fire extinguishing composition is discharged. The nozzle 1 comprises a mixing chamber 2, a ventilation chamber 3 and a foaming chamber 4. Notwithstanding the mixing chamber 2, the ventilation chamber 3 and the foaming chamber 4 are formed as a single, indivisible body, the ratio of the axial length over the inner diameter (L:d) of the foaming chamber 4 is unambiguously determined between 6:1 and 10:1. The ventilation chamber 3 comprises four air inlet holes 6, allowing for contact between ambient air and the fire extinguishing composition passing through the nozzle 1. For ease of coupling and/or decoupling the nozzle 1 to a fire extinguisher or fire extinguisher hose, an outer thread 12 is provided at the inlet a. By using the nozzle 1 as herein

described, the discharged fire extinguishing foam is more compact and thicker than fire extinguishing foams which are discharged through nozzles as generally known in the art. This is particularly advantageous for class B fires, as the fire extinguishing foam is intended to form a substantive layer on top of the burning liquid surface. The resulting compact and thick foam layer is able to better contain the flames in a certain area, and thus prevents the further spreading of the fire. Meanwhile, contact between the burning liquid and ambient air is efficiently reduced and/or eliminated, resulting in liquid fires being more rapidly extinguished. It is further submitted that the nozzle as herein described further enhances foam expansion of the fire extinguishing composition according to the invention.

[0094] Fig. 3a shows a perspective view of an embodiment of a fire extinguishing nozzle 1 for using the formulation according to the present invention for extinguishing class A and B fires, which nozzle 1 comprises three separate and/or detachable parts, i.e. a mixing chamber 2, a ventilation chamber 3 and a foaming chamber 4. The nozzle 1 is especially useful for extinguishing class A fires and is to be understood having an inlet a and an outlet b. Fig. 3b shows a perspective view of the same embodiment of the fire extinguishing nozzle 1 in a disassembled state. The mixing chamber 2, the ventilation chamber 3 and the foaming chamber 4 are herein recognizable as three separate entities. For ease of coupling and/or decoupling said parts, outer threads 12 are provided at the inlet a of the mixing chamber 2, at the outlet of the mixing chamber 2, and at the outlet of the ventilation chamber 3. Compatible inner threads 11 are provided at the inlet of the ventilation chamber 2 and at the inlet of the foaming chamber 4. The ratio of the axial length over the inner diameter (L:d) of the foaming chamber 4 is furthermore unambiguously determined between 4:5 and 9:5. The ventilation chamber 3 comprises four air inlet holes 6, allowing for contact between ambient air and the fire extinguishing composition passing through the nozzle 1. The ventilation chamber 3 further comprises a mesh 7, which impacts various foaming characteristics, such as the discharge time, the discharge flow, foam expansion, foam bubble size, foam discharge angle etc. By using the nozzle 1 as herein described, the foaming characteristics of a fire extinguishing composition are altered as such, that the fire extinguishing composition can be optimally used to extinguish class A fires in a fast and efficient way.

[0095] Fig. 4a shows a perspective view of an embodiment of an assembled fire extinguishing nozzle 1 for using the formulation according to the present invention for extinguishing class A and B fires, which nozzle 1 comprises three separate and/or detachable parts, i.e. a mixing chamber 2, a ventilation chamber 3 and a foaming chamber 4. The nozzle 1 is especially useful for extinguishing class B fires and is to be understood having an inlet a and an outlet b. Fig. 4b shows a perspective view of the same embodiment of the fire extinguishing nozzle 1 in a disassembled state. The mixing chamber 2, the ventilation chamber 3 and the foaming chamber 4 are herein recognizable as three separate entities. For ease of coupling and/or decoupling said parts, outer threads 12 are provided at the inlet a of the mixing chamber 2, at the outlet of the mixing chamber 2, and at the outlet of the ventilation chamber 3. Compatible inner threads 11 are provided at the inlet of the ventilation chamber 2 and at the inlet of the foaming chamber 4. The ratio of the axial length over the inner diameter (L:d) of the foaming chamber 4 is furthermore unambiguously determined between 6:1 and 10:5. The ventilation chamber 3 comprises four air inlet holes 6, allowing for contact between ambient air and the fire extinguishing composition passing through the nozzle 1. The ventilation chamber 3 further comprises a mesh 7, which impacts various foaming characteristics, such as the discharge time, the discharge flow, foam expansion, foam bubble size, foam discharge angle etc. By using the nozzle 1 as herein described, the foaming characteristics of a fire extinguishing composition are altered as such, that the fire extinguishing composition can be optimally used to extinguish class B fires in a fast and efficient way.

[0096] Fig. 5 shows a perspective view of an embodiment of a ventilation chamber 3 for using the formulation according to the present invention for extinguishing class A and B fires, comprising air inlet holes 6 and a mesh 7. For ease of coupling and/or decoupling the ventilation chamber 3 to other parts of the nozzle, an outer thread 12 is provided.

[0097] Fig. 6 shows a perspective view of an embodiment of a ventilation chamber 3 and a foaming chamber 4 for using the formulation according to the present invention for extinguishing class A and B fires, which ventilation 3 and foaming chamber 4 form a single, indivisible body. Notwithstanding the ventilation chamber 3 and the foaming chamber 4 are formed as a single, indivisible body, the ratio of the axial length over the inner diameter (L:d) of the foaming chamber 4 is unambiguously determined between 4:5 and 9:5. Fig. 6 further serves to illustrate the first hollow cylindrical body 5 of the ventilation chamber 3, which internally is provided with an inner thread 11, to provide for easy coupling and/or decoupling to a mixing chamber, and comprises four air inlet holes 6.

[0098] Fig. 7 shows a perspective view and a cross-sectional inlet view of an embodiment of a mixing chamber 2 for using the formulation according to the present invention for extinguishing class A and B fires. The mixing chamber 2 comprises two constricted inlet holes 8, which allow for enhancing the velocity and the turbulence of the liquid flow of a fire extinguishing composition before entering a ventilation chamber. Easy coupling of said mixing chamber 2 to an upstream fire extinguisher and a downstream ventilation chamber is provided for by the outer threads 12. The mixing chamber further comprises an elongated outlet 9 which is configured as such that it efficiently guides a fire extinguishing composition inside and/or at least halfway through a ventilation chamber coupled thereto.

[0099] Fig. 8 shows a sectional representation according to a central, axial axis of an embodiment of a ventilation chamber 3 for using the formulation according to the present invention for extinguishing class A and B fires. The ventilation chamber 3 comprises air inlet holes 6 and is provided with a mesh 7 and an outer thread 12, for easy coupling to a

foaming chamber. The first hollow cylindrical body **5**, in particular the inner cross-section of the ventilation chamber **3**, comprises a cross-sectional constriction **10**, which is shaped as a venturi-like necking. This induces the venturi effect inside the first hollow cylindrical body **5**, thereby drawing air through the air inlet holes **6** of the ventilation chamber **3**.

5 List of numbered elements:

[0100]

- 1 fire extinguishing nozzle
- 10 2 mixing chamber
- 3 ventilation chamber
- 4 foaming chamber
- 5 first hollow cylindrical body
- 6 air inlet hole
- 15 7 mesh
- 8 constricted inlet hole
- 9 elongated outlet
- 10 cross-sectional constriction
- 11 inner thread
- 20 12 outer thread
- a inlet
- b outlet
- L axial length
- d inner diameter

Claims

1. A fluorine-free fire extinguishing formulation comprising:

- a fire retardant agent chosen from the group of ammonium phosphates, phosphate esters, halogenated phosphates, phosphonates, red phosphorus, calcium silicate, sodium silicate, aluminium trihydroxide, magnesium dihydroxide, melamine, polybrominated diphenyl ethers (PBDE), tetrabromobisphenol A (TBBPA), hexabromocyclododecane (HBCD), brominated phenol, or combinations thereof,
- a mixture of at least two different amphoteric surfactants,
- a mixture of at least two different anionic surfactants,
- an organic solvent, and
- water,

characterized in that, said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,10 and 5,00 wt.% and of between 0,10 and 5,00 wt.% based on the total weight of the fire extinguishing formulation.

2. The fire extinguishing formulation according to claim 1, **characterized in that**, said mixture of amphoteric surfactants and said mixture of anionic surfactants are respectively present in a concentration of between 0,25 and 1,50 wt.% and of between 0,50 and 2,00 wt.% based on the total weight of the fire extinguishing formulation.

3. The fire extinguishing formulation according to claim 1 or 2, **characterized in that**, said mixture of amphoteric surfactants comprises at least three different amphoteric surfactants, and said mixture of anionic surfactants comprises at least three different anionic surfactants.

4. The fire extinguishing formulation according to any one of preceding claims 1-3, **characterized in that**, said organic solvent has a concentration of between 2,50 and 10,00 wt.% based on the total weight of the fire extinguishing formulation.

5. The fire extinguishing formulation according to any one of preceding claims 1-4, **characterized in that**, said fire extinguishing formulation comprises a foam stabilizer, said foam stabilizer is present in a concentration of between 0,10 and 5,00 wt.% based on the total weight of the fire extinguishing formulation.

6. The fire extinguishing formulation according to any one of preceding claims 1-5, **characterized in that**, said fire extinguishing formulation comprises a heat stabilizer, said heat stabilizer is present in a concentration of between 0,50 and 10,00 wt.% based on the total weight of the fire extinguishing formulation.

7. The fire extinguishing formulation according to any one of preceding claims 1-6, **characterized in that**, the fire retardant agent is present in a concentration of between 1,50 to 10,00 wt.% based on the total weight of the fire extinguishing formulation.

8. The fire extinguishing formulation according to any one of preceding claims 1-7, **characterized in that**, said fire extinguishing formulation comprises:

- between 1,50 and 10,00 wt.% of fire retardant agent;
- between 0,25 and 1,50 wt.% of amphoteric surfactants;
- between 0,50 and 2,00 wt.% of anionic surfactants;
- between 0,50 and 2,00 wt.% of foam stabilizer;
- between 0,50 and 10,00 wt.% of heat stabilizer;
- between 2,50 and 10,00 wt.% of organic solvent; and
- between 50,00 and 95,00 wt.% of water.

9. The fire extinguishing formulation according to any one of preceding claims 1-8, **characterized in that**, said amphoteric surfactants are chosen from the group of betaines, sultaines, alkylamphoacetates, amphodiacetates, alkylamphopropionates, alkyliminodipropionates, amphodipropionates, aliphatic quaternary ammonium compounds, aliphatic quaternary phosphonium compounds, aliphatic quaternary sulfonium compounds, their derivatives or combinations thereof.

10. The fire extinguishing formulation according to any one of preceding claims 1-9, **characterized in that**, said anionic surfactants are chosen from the group of alkyl sulfates, alkyl ether sulfates, alkyl ether sulfonates, sulfate esters of an alkylphenoxy polyoxyethylene ethanol, alcohol ammonium sulfates, alpha-olefin sulfonates, beta alkoxy alkane sulfonates, alkylauryl sulfonates, alkyl monoglyceride sulfates, alkyl monoglyceride sulfonates, alkyl carbonates, alkyl ether carboxylates, fatty acids, fatty alcohol sulfates, sulfosuccinates, sarcosinates, octoxynol or nonoxynol phosphates, taurates, fatty taurides, fatty acid amide polyoxyethylenes, isethionates, anionic derivatives of alkyl polyglucosides, or combinations thereof.

11. The fire extinguishing formulation according to any one of claims preceding claims 1-10, **characterized in that**, said organic solvent is chosen from the group of ethylene glycol, propylene glycol, butyl-di-glycol, dipropylene glycol n-propyl ether, dipropylene glycol n-butyl ether, propylene glycol n-butyl ether, propylene glycol, n-propyl ether, tripropylene glycol n-butyl ether, propylene glycol phenyl ether, dipropylene glycol phenyl ether, dipropylene glycol dimethyl ether, propylene glycol methyl ether, propylene glycol methyl ether acetate, dipropylene glycol methyl ether, dipropylene glycol methyl ether acetate, tripropylene glycol methyl ether, ethylene glycol hexyl ether, diethylene glycol hexyl ether, ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol monopropyl ether, ethylene glycol monoisopropyl ether, ethylene glycol, monobutyl ether, ethylene glycol monobenzyl ether, diethylene glycol phenyl ether, ethylene glycol phenyl ether, poly(oxy-1,2-ethanediyl), alpha-phenyl-omega-hydroxy, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol n-butyl ether, ethylene glycol n-butyl ether, dipropylene glycol methyl ether, or combinations thereof.

12. Use of the fire extinguishing formulation according to any one of preceding claims 1-11 for extinguishing class A or class B fires, **characterized in that**, extinguishing class A or class B fires is performed by means of a fire extinguisher comprising said fire extinguishing formulation.

13. Use according to claim 12, **characterized in that**, said fire extinguisher comprises a fire extinguishing nozzle (1), said nozzle comprising a mixing chamber (2), a ventilation chamber (3) and a foaming chamber (4), wherein

- said ventilation chamber is coupled to said mixing chamber, and comprises a first hollow cylindrical body (5) comprising at least three air inlet holes (6), said air inlet holes are arranged on the circumference of, and are directed into the first hollow cylindrical body;
- said foaming chamber comprises a second hollow cylindrical body having an axial length (L) and an inner diameter (d), which foaming chamber is coupled to said ventilation chamber; and
- said ventilation chamber and/or said foaming chamber comprise a mesh (7), wherein said mesh is oriented

in the radial plane of the inner cross-section of the ventilation chamber and/or foaming chamber;

characterized in that, the ratio of the axial length over the inner diameter (L:d) of the foaming chamber is comprised between 4:5 and 9:5 for extinguishing class A fires, or between 6:1 and 10:1 for extinguishing class B fires.

5
14. Use according claim 13, **characterized in that**, said mesh (7) has a mesh size of between 700 and 1200 μm , preferably between 800 and 1100 μm .

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15. A fire extinguisher comprising a fire extinguishing formulation according to any one of claims 1-11, **characterized in that**, said fire extinguisher comprises a fire extinguishing nozzle (1), said nozzle comprising a mixing chamber (2), a ventilation chamber (3) and a foaming chamber (4), wherein

- said ventilation chamber is coupled to said mixing chamber, and comprises a first hollow cylindrical body (5) comprising at least three air inlet holes (6), said air inlet holes are arranged on the circumference of, and are directed into the first hollow cylindrical body;

15
- said foaming chamber comprises a second hollow cylindrical body having an axial length (L) and an inner diameter (d), which foaming chamber is coupled to said ventilation chamber; and

- said ventilation chamber and/or said foaming chamber comprise a mesh (7), wherein said mesh is oriented in the radial plane of the inner cross-section of the ventilation chamber and/or foaming chamber;

20
characterized in that, the ratio of the axial length over the inner diameter (L:d) of the foaming chamber is comprised between 4:5 and 9:5 for extinguishing class A fires, or between 6:1 and 10:1 for extinguishing class B fires.

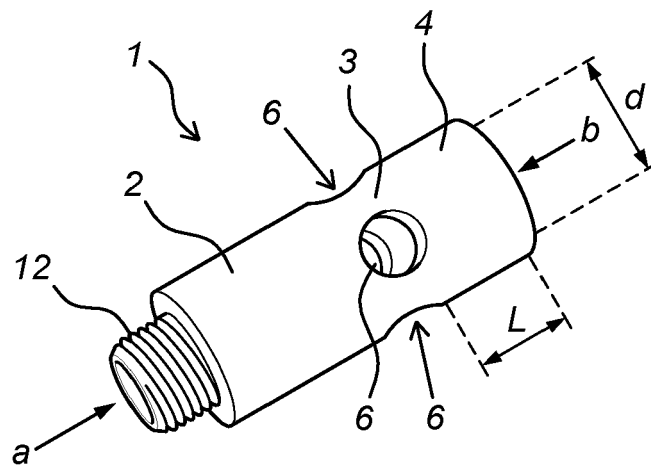


Fig. 1

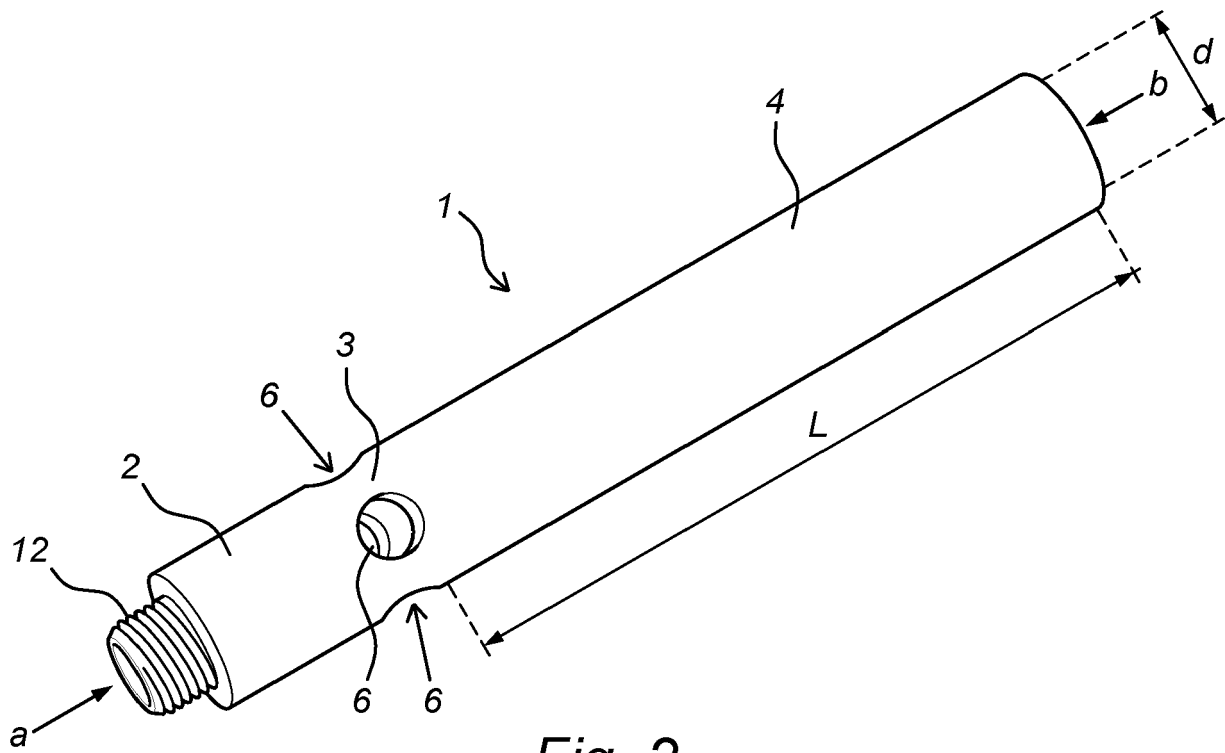


Fig. 2

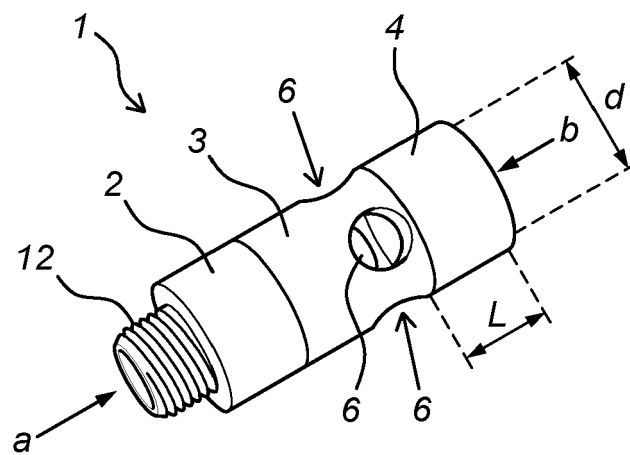


Fig. 3a

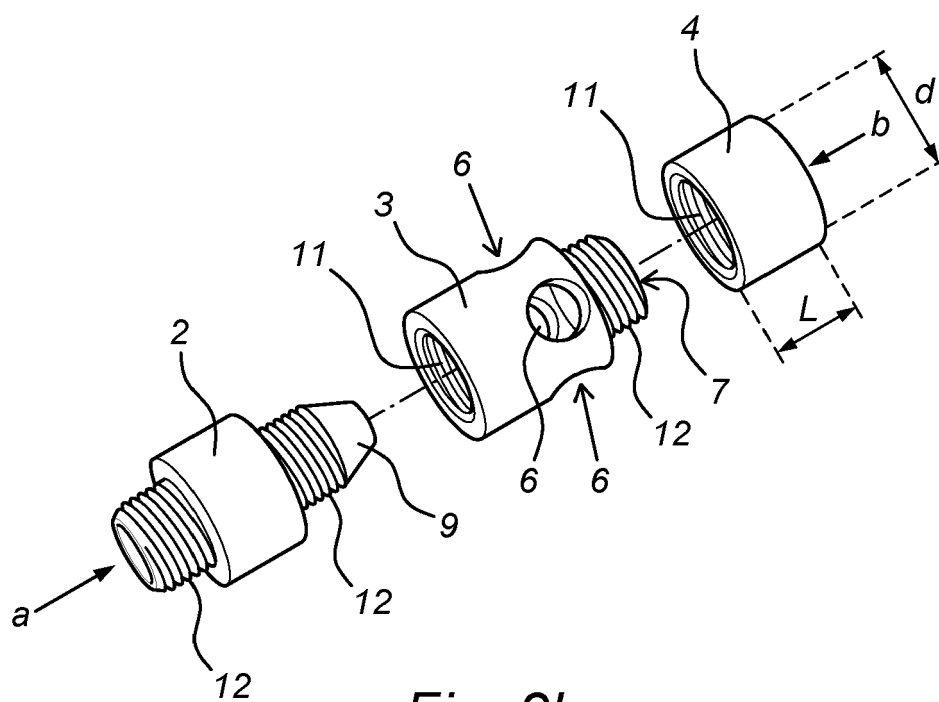
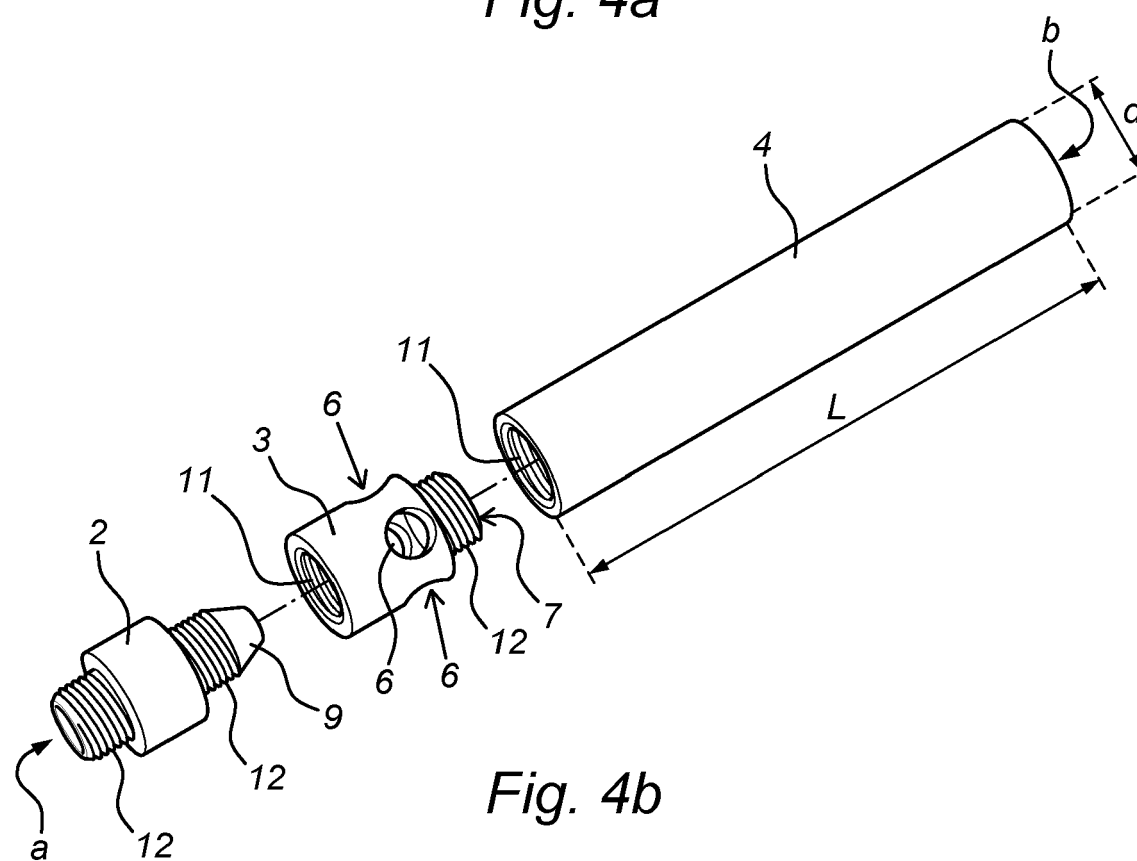
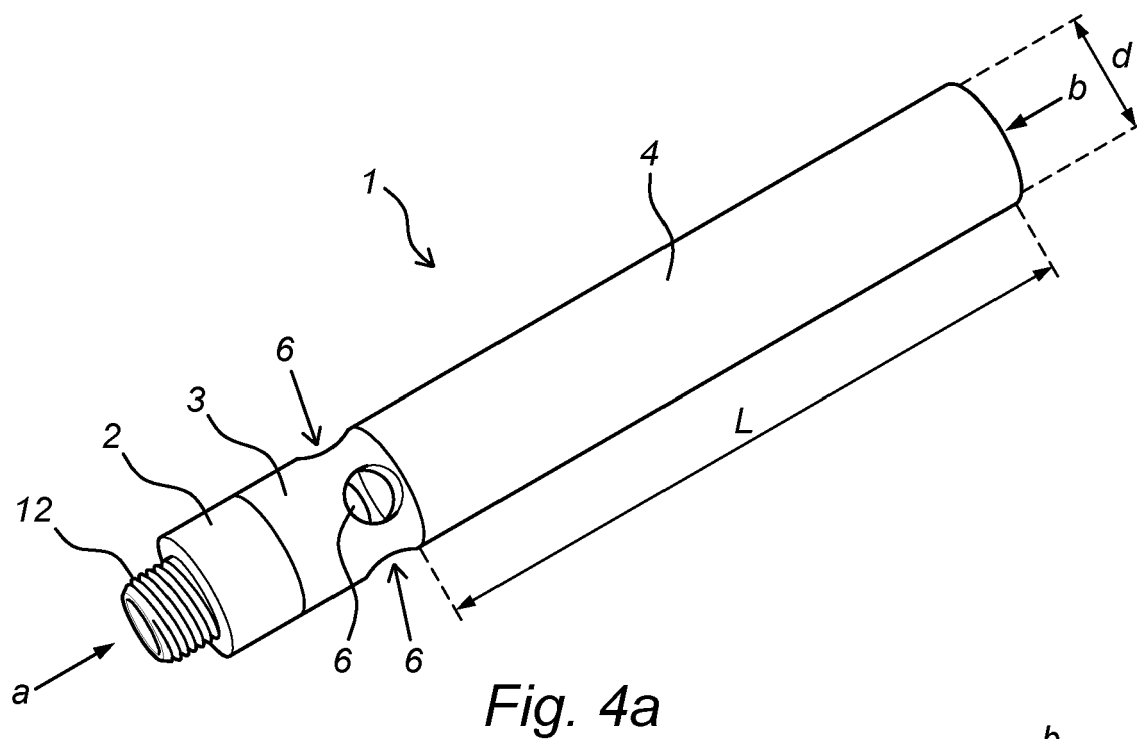


Fig. 3b



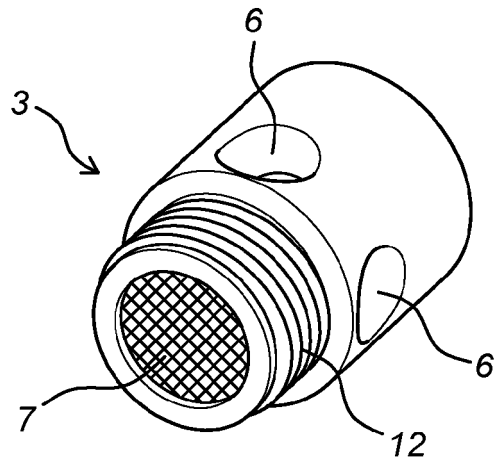


Fig. 5

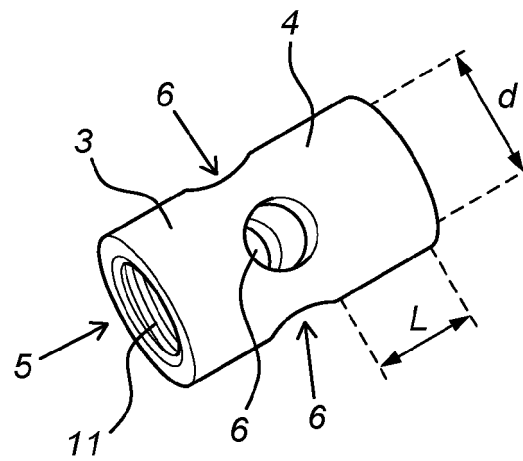


Fig. 6

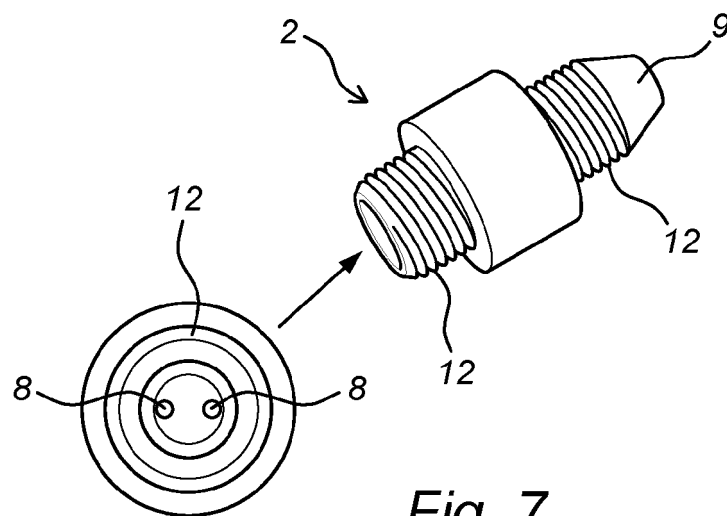


Fig. 7

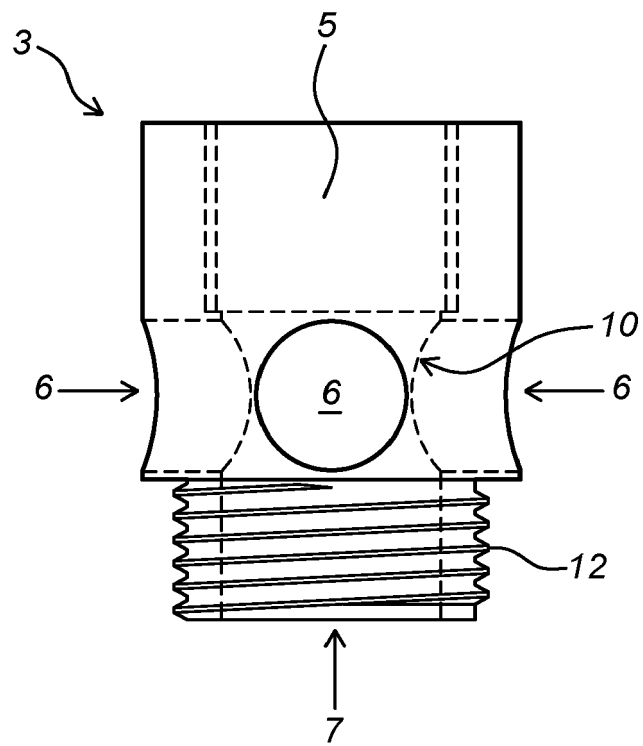


Fig. 8



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