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Remarks:
If details are not fully discernible, that is due to the quality of the drawings filed by the applicant.

(54) FIRE EXTINGUISHING APPARATUS

(57) Described is a water mist fire extinguishing apparatus (10), a use of said device and a method for a first attack on the fire. The water mist fire extinguishing apparatus (10) is a device configured to be functionally and temporally autonomous to attack the fire for up to a maximum time of 300 sec., it has a total weight of less than 80 kg and is transportable, also by hand. More specifically, the device comprises the following components: an energy accumulator (18), a pressure generator (12), a nebulizing device (20), a liquid tank (25), connected to the pressure generator (12), a control device (30) for controlling the pressure generator (12) and a tube (17) having a first end connected to the pressure generator (12) and a second end connected to the nebulizing device (20) of a special type. -

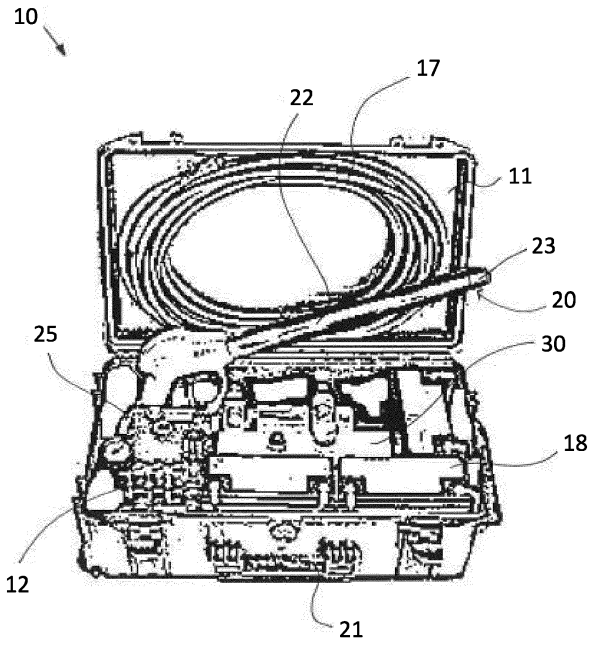

FIG. 1

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Description

[0001] This invention relates in general to a apparatus for extinguishing a fire. In particular, the invention relates to a so-called first fire attack apparatus, that is to say for extinguishing a fire which is in the initial stage.

[0002] Even more particularly, the fire extinguishing apparatus according to the invention is an apparatus that makes use of water mist (WM) technology. In the following description, such a apparatus is called a water mist fire extinguishing apparatus.

[0003] The term water mist is a well-known and well-defined term in the field of fire-fighting appliances and equipment and generally refers to a technology for extinguishing a fire by means of a mist of water droplets.

[0004] In particular, the water mist technology is a technology in accordance with certain international standards and satisfies the need to extinguish the slightest start of a fire with the use of very little water and is particularly useful for avoiding, unlike traditional systems with tanks, many litres of water with evident damage from flooding, and which determine a destruction of the environment.

[0005] A water mist technology uses lower flow rates, in the order of 8 litres/min at high pressure, such as, for example, 90 bar.

[0006] The use of water mist as an extinguishing medium has gained popularity in the fire management activities due to the advantage shown, particularly in confined areas, by its efficiency in extracting heat, displacing oxygen and attenuating radiant heat using minimal quantities of pure water. However, this technique has until now been mainly related, but not limited, to static applications, such as for example offices, hospitals, retirement homes, cruise ships, theatres, museums and where the combination of efficiency with protection against damage prevails over the use of large quantities of water, as in the case of sprinkler systems, or the use of unsafe extinguishing products such as foams and powders which are destined to cause damage to important products, e.g. PCs, TVs, electronic devices, etc. or valuables, e.g. paintings, decorations, etc. as mentioned above.

[0007] In particular, the prior art water mist apparatuses have a heavy weight of around or even greater than 130 kg, and may not therefore be transported by an operator through narrow spaces, such as for example corridors of submarines, small boats and aircraft cabins, and allow areas close to the start of the fire, wherever they are, to be reached. In other words, this apparatus is not a transportable apparatus, that is to say, it may not be handled or moved only with the physical force of a single operator.

[0008] Furthermore, a key point of the water mist technology is represented by the high efficiency demonstrated by the quality of the water mist jet where the correct dispersion of the size of the droplets, obtained with special nozzles, from a few microns up to 200 microns, guarantees maximum efficiency for the first attack especially in confined areas. In particular, it is known that the greater the degree of nebulization, that is, the smaller the size of each droplet with the same flow rate, the greater is the water-combustion gas contact surface, which corresponds to a higher evaporation rate for water with a drastic effect of cooling on the fire and at the same time increased rate of oxygen displacement and thermal barrier formation as the droplets act as a gas-like agent.

[0009] At the basis of the invention there is a recognition by the author of invention that the known water mist fire extinguishing apparatus has limitations of use and functionality, and that it may be improved in order to expand the possibilities and functionality of use both in terms of sites where it may be used and to improve/optimise the fire attack times.

[0010] A technical problem underlying the invention resides in providing a respective water mist fire extinguishing apparatus with an improved functionality compared to prior art appliances, as well as achieving further advantages.

[0011] This is achieved by providing a water mist fire extinguishing apparatus, a use and a method according to the respective independent claims. Secondary characteristics of the above-mentioned apparatus, use and method are defined in the corresponding dependent claims.

[0012] The water mist fire extinguishing apparatus according to the invention is an apparatus having a total weight of less than or equal to 80 kg and configured to be transportable and functionally and temporally autonomous to attack the fire for up to a maximum time of 300 sec. The fire-fighting apparatus according to the invention further includes at least the following components:

- an energy accumulator
- a pressure generator,
- a nebulizing device,
- a liquid tank, configured to be connected to the pressure generator,
- a control device for controlling the pressure generator and
- a tube having a first end configured to be connected to the pressure generator and a second end configured to be connected to the nebulizing device.

[0013] In the context of the invention, a pressure generator preferably means a device comprising a motor, for example

an electric motor, and a pump wherein the motor drives the pump. Preferably, the pump is coupled to the motor through a respective coupling joint.

[0014] In practice, a water mist fire extinguishing apparatus is made available which includes all the components necessary to be autonomous and which is also transportable, preferably by hand. The water mist fire extinguishing apparatus is therefore freely transportable, with no restrictions to perform its function.

[0015] In the context of the invention, the term "transportable" means a device or apparatus which, in addition to being autonomous, may also be carried or moved by a single person to the site of the intervention, more precisely up to close to the start of the fire. In other words, the apparatus may be handled or moved, close to the start of a fire, even only with the physical force of a single operator. The total weight of the apparatus of below 80 kg allows, in fact, a single operator to transport the appliance, even manually, to the site of the first attack on the fire. In other words, the apparatus is light enough to be moved or handled by a single operator even when he/she is forced to pass through confined spaces.

[0016] More specifically, the apparatus according to the invention is configured to be functionally and temporally autonomous, that is, to have a period of autonomy of attack to limit the fire, for a limited period of time and in particular up to a maximum time of 300 seconds. The autonomy may be for a certain initial period of time since, during this initial period of time, the apparatus may work with the integrated tank. That is to say that the apparatus is configured in such a way that it may operate individually, that is, without the need for connection to external sources, only for a first period of time, or initial period of time, equal to a maximum of 300 seconds, after which the apparatus must be connected to an external source in order to function.

[0017] In practice, the water mist fire extinguishing apparatus is configured to be transported, preferably by hand, to the site of the first attack on the fire, that is to say, close to the start of the fire, without having to depend on external power sources, for example from a vehicle or other form of E-power and without necessarily having to depend on external water supply, at least for an initial time for attack on the fire.

[0018] In other words, the apparatus according to the invention is conceived to be of the autonomous type, independent of external energy sources, and transportable by an operator.

[0019] Preferably, the water mist fire extinguishing apparatus includes at least one support structure for supporting said components. Alternatively, the water mist fire extinguishing apparatus includes two or more support structures, wherein a support structure supports some of said components and a second support structure supports the remaining components.

[0020] For example, the water mist fire extinguishing apparatus includes a first support structure for supporting the energy accumulator, pressure generator, nebulizing device, control device and tube. A second support structure may be provided to support the tank. The two support structures may be transportable independently of each other in order to distribute the weight of the components between the two support structures. The tube and/or the nebulizing device may be housed on the second support structure together with the tank. The distribution of the components may be chosen according to the transport needs.

[0021] Even more preferably, both the first support structure and the second support structure may be provided with a liquid tank, in such a way as to increase the quantity of liquid available and the autonomy time of the water mist fire extinguishing apparatus.

[0022] In the context of the invention, the term "liquid" generally refers to a fluid, for example water, suitable for water mist technology.

[0023] The support structure may be a container body, such as a containment box, for example configured like a suitcase, with a possible appropriate handgrip, and which allows the typical performance levels of water mist technology to be combined with autonomy and handling requirements. The support structure may alternatively be configured as a generic support framework which is transportable, and possibly also in a wearable form. The first support structure may be configured as a suitcase, the second support structure may be configured as a wearable frame, for example a backpack, or similar harness that may be worn on the back. In this way the weights of the above-mentioned components may be distributed.

[0024] One or both of the support structures may be provided with a trolley, or with wheels to facilitate and further ease the transport.

[0025] With the water mist fire extinguishing apparatus according to the invention it is possible to have access to very small restricted areas, such as engine rooms, small ships, for example submarines, and the like. Moreover, the water mist fire extinguishing apparatus is particularly advantageous when the building or premises are very large. In fact, even in the case of large buildings, the use of one or more water mist fire extinguishing apparatuses may be advantageous since, being transportable, it avoids the installation of a significant static fire-extinguishing system. In other words, it is not necessary to provide several fixed and permanent systems, as it is sufficient to carry one or a small number of water mist fire extinguishing apparatuses to the site by hand. Moreover, the water mist fire extinguishing apparatus may also be configured to be connected immediately or at a later time to an external water supply system with an optional extension pipe. In other words, the water mist fire extinguishing apparatus, after having finished the period of time of less than 300 seconds, in which it is configured, to be functionally and temporally autonomous, that is to say it has been shown to be

able to provide autonomous operation, may be connected to an external water source. This gives time to attack the fire immediately and during the first attack time to connect the apparatus to an external supply. The possibility of immediately containing the fire is therefore not lost, and fire management times are optimized.

[0026] The water mist fire extinguishing apparatus according to the invention allows it to be moved to the fire point so as to immediately contain the fire. The water mist fire extinguishing apparatus according to the invention may be brought close to the start of the fire to promptly prevent its propagation.

[0027] However, in the event that the apparatus is already positioned at a water supply point, even of minimal dimensions (e.g. ½" or ¾" connection) and there is no certainty of the extent of the fire, the firefighters may head towards the fire holding only the lance and very lightweight extensions, which may be easily positioned equipped with quick connection fittings in order to reach even the furthest points from the fire without having to worry about whether the small tank available, or the at least two tanks, may or may not be sufficient to effectively attack the fire.

[0028] In other words, if an additional water supply is required, for example if the fire is not extinguished, and the extinguishing time exceeds the maximum autonomous operating time of 300 seconds, it is still possible to connect the apparatus to an external source. This therefore avoids having to delay the extinguishing of the start of the fire in order to lengthen the tube with the risk of having to face an increase in the fire and not being able to make a true first attack on the fire, in order to reach all the points of a room exposed to fire.

[0029] In other words, by means of the water mist fire extinguishing apparatus according to the invention, a first attack on the fire with water mist technology may be carried out for a rapid, precise and targeted extinguishing in areas of difficult access and in many restricted areas including pleasure and military boats (living areas, engine room and operational areas).

[0030] The operation of the apparatus is substantially performed by means of the above-mentioned pressure generator, preferably a pump driven by an electric motor powered by dedicated batteries, which power the nebulizing device, such as preferably a hand lance capable of producing a water mist spray for extinguishing fires.

[0031] Thanks to the water mist technology, the following main advantages are obtained:

to. Rapid cooling of the fire by heat extraction,

b. Dilution of oxygen through the production of water vapour,

c. Control of radiant heat by means of a vapour barrier,

d. Reduced water consumption, limiting the induced damage.

[0032] In other words, with the water mist fire extinguishing apparatus according to the invention, all the advantages of a water mist technology may also be maintained, such as

- Efficient performance levels due to the high cooling effect, oxygen displacement and heat barrier;
- Low water requirement which, being nebulized, evaporates completely without wetting;
- Ecological approach since just water may be used;
- Nebulized water not dangerous for people or animals accidentally struck by the jet, even at close range, for example less than 30 cm;
- Nebulized water that does not damage valuables, such as TVs, PCs, paintings, furniture, decorations, etc., as may happen, on the other hand, if extinguishing powders or foams are used.

[0033] According to the context of the invention, the term water mist means an apparatus which, regardless of its technical structure and configuration, is capable of emitting a nebulized jet.

[0034] In other words, the main feature of a water mist system is to use water in finely divided droplets, such as to optimize the combination of heat extraction, inertization and blocking of radiant heat, that is to say, factors that have proved particularly effective in the extinguishing action.

[0035] Another feature of a water mist system is the minimum quantity of water that is used in controlling a possible fire. The typical flow rates of the water mist nozzles are in fact much lower, even centesimal compared to traditional full jet extinguishing systems, as their very fine nebulization increases the contact surface and therefore the heat exchange in an extraordinary manner.

[0036] For example, in the case of a water mist nozzle that complies with the NFPA 750-USA class 1 standard, that is, with a droplet diameter of around 100 microns, the ratio of the surface developed by the droplets to that of 1 litre of water exceeds the value of 500. A Water Mist system, or rather a Fine Water Spray system is therefore substantially a system capable of delivering water in finely divided droplets, directed appropriately with respect to the area to be protected and in an adequate quantity to extinguish the hypothetical fire, maximising the efficiency of the water supply, that is, in such a way that the entire flow rate is vaporised by the heat of combustion without wetting the floor, walls and objects and therefore avoiding the indirect damage created by a traditional fire-fighting intervention, that is, with a traditional water jet or with extinguishing powders or foams.

[0037] The water mist technology according to the invention is currently a technology accurately encoded by the NFPA 750 standard. For example, referring to the size of the water droplets, the water mist technology thus defines a nebulized jet in which the droplet size is less than 1000 μm for 99% of the total droplets dispensed. The water mist systems have been classified into 3 classes, depending on the droplet size with values up to 200 μm for Class 1 systems and gradually higher, up to 1000 μm in the Class 3 systems.

[0038] The water mist technology is mainly used in static systems with indicative pressures of between 10-30 bar, while the systems that exceed this value, generally of the mobile type such as that of the invention, are called high pressure and may even reach 300 bar.

[0039] Further advantages, characteristics and methods of use of the object of the invention will become evident from the following detailed description of some of its preferred embodiments, presented merely by way of non-limiting example.

[0040] It is however evident that each embodiment of the object of this invention may have one or more of the advantages listed above; however, no embodiment is required to simultaneously have all the listed advantages.

[0041] Reference will be made to the accompanying drawings, in which:

- Figure 1 is a front view of a water mist fire extinguishing apparatus in an open condition according to an embodiment of the invention;
- Figure 2 is an axonometric view of the water mist fire extinguishing apparatus of Figure 1 in a closed condition, in which the possible dimensions of the apparatus are indicated;
- Figure 3 is a schematic view of a water mist fire extinguishing apparatus in order to show the components present therein;
- Figure 4 is a side view of a nozzle of a water mist fire extinguishing apparatus according to an embodiment of the invention.
- Figure 5 is an isometric view in an exploded condition of the nozzle of Figure 4;
- Figure 6 is a sectional view of the nozzle of Figure 4;
- Figure 7 is a sectional view of the nozzle of Figure 4 with parts detached;
- Figures 8 and 9 show two graphs indicating the speed and dimensions of the droplets (measured on the basis of tests carried out with the Phase Doppler technique) inside a jet flowing out from the nozzle applied in a apparatus according to the invention and from a state of the art nozzle.

[0042] With reference to the accompanying drawings, a water mist fire extinguishing apparatus according to the invention is denoted in its entirety with the reference numeral 10. According to an important aspect of the invention, the water mist fire extinguishing apparatus is a transportable and functionally and temporally autonomous apparatus.

[0043] The term "transportable" means a apparatus that may be transported, that is to say, moved or handled even just with the physical strength of a single operator. In this way, the apparatus is preferably but not exclusively movable by hand by a single user, such as a fireman.

[0044] According to the embodiment illustrated, the apparatus includes a support structure, for example configured like a suitcase, or case and may be provided with a handgrip 21. The support structure may preferably be provided with a trolley, or with wheels to facilitate and further ease the transport.

[0045] The expression "functionally autonomous" means a apparatus that does not require external components in order to function, that is to say, an apparatus that does not necessarily have to be connected to any other component, which is not already part of the apparatus itself, in order to be functional, that is, to make the water mist apparatus work. For example, the apparatus does not necessarily have to be connected to an external electrical power supply and an external source of liquid L is not necessarily needed. In yet other words, the apparatus does not require, in order to carry out its function, external inputs, or sources external to the water mist fire extinguishing apparatus 10.

[0046] It is to be understood that the possibility of increasing the duration of the functionality of the water mist fire extinguishing apparatus 10 may be envisaged by connecting the appliance to external water sources.

[0047] The total weight of the water mist fire extinguishing apparatus 10 according to the invention is less than or equal to 80 kg, for example between about 70 kg and 30 kg, preferably between 55 kg and 35 kg, even more preferably less than 50 kg.

[0048] The above-mentioned functional and temporal autonomy of the water mist fire extinguishing apparatus 10 is at least an autonomy to be able to carry out a very first attack on the fire, and to attack the fire for up to a maximum time equal to 300 seconds. In other words, the water mist fire extinguishing apparatus is configured to be functionally and temporally autonomous for a maximum time of less than 300 sec. Preferably, this maximum time is between 300 sec. and 15 sec., preferably between 300 sec. and 45 sec., preferably between 240 sec. and 50 sec., even more preferably between 180 sec. and 60 sec., for example about 120 sec.

[0049] The water mist fire extinguishing apparatus 10 comprises a containment box 11, having the function of said support structure, and the following functional components are housed inside said containment box 11 to perform the water mist fire-fighting function independently, that is, a liquid tank 25, preferably an aqueous solution, or plain water L,

a tube 17, preferably a rubber hose, a pressure generator 12 connected to the tank and configured to pressurize the liquid towards a first end of the flexible tube, a nebulizing device 20 located at a second end of the flexible tube, an energy accumulator 18, and a control device 30 for controlling the pressure generator 12.

[0050] Preferably, the water mist fire extinguishing apparatus 10 has reduced overall dimensions, that is to say, a reduced volume. The overall dimensions, or volume, are less than 400mm X 600mm X 800mm. More preferably, the overall dimensions or volume is less than 350mm X 550mm X 750mm, and even more preferably less than or equal to 290mm X 520mm X 650mm. The water mist fire extinguishing apparatus 10 is therefore particularly compact. This makes it easier to transport and move, especially in confined places.

[0051] The energy accumulator 18 is connected in a known manner to a pressure generator 12 and a control device 30 to allow its operation. The control device 30 may be a set of elements intended to regulate the operation of the pressure generator, or only its switching on.

[0052] Alternatively, according to embodiments not illustrated but falling within the scope of the invention, the water mist fire extinguishing apparatus 10 and a support structure, and the above-mentioned functional components are arranged partly in one support structure (first support structure) and partly on the other support structure (second support structure). For example, the at least one tank and possibly also the tube may be supported on the second support structure, while the remaining functional components may be arranged inside said containment box 11 to perform the water mist fire extinguishing function autonomously.

[0053] A second tank supported on the first support structure may also be provided.

[0054] If there are two tanks, the second tank is connected as necessary to the other components to make the water reserve available. A person skilled in the art may understand that the above-mentioned components may be functionally organised in the most suitable way to allow the fire extinguishing function to be carried out.

[0055] According to the embodiment illustrated, the pressure generator 12 includes a pump 13 and a motor 15, for example electric, which drives the pump 13. The motor 15 is of adequate power and, as it should be, is provided with both control (pressure regulator and pressure gauge) and safety (safety valve) components; these control and safety components are known to a person skilled in the art and are not visible in the drawings; preferably the motor 15 is an electric motor with permanent magnets with a joint for connection with the pump 13; this electric motor has the advantage of being silent and making the water mist fire extinguishing apparatus compatible with use in environments that may have other noises due to the dangerous situation in progress.

[0056] The tube 17 is, as mentioned, preferably a rubber tube, which is preferably equipped with reinforcing spirals having a given length with a working pressure that satisfies a predetermined safety factor K = 2.5 (Burst Press / Spec press) defined by the international standards.

[0057] The energy accumulator or battery 18 is preferably a lead accumulator, that is to say a battery which is as compatible as possible with an environment in which there is a fire or a beginning of fire. Alternatively, the battery may be a lithium battery.

[0058] The nebulizing device 20 preferably includes a manual lance 22 and a nozzle 23, as indicated below.

[0059] The liquid tank 25 is configured to contain a limited amount of water for example less than 30 litres. If there are several tanks, the quantity of liquid may increase overall, for example up to 55 litres, and consequently also the autonomy of the water mist fire extinguishing apparatus. For example, a tank with a capacity of less than or equal to 30 litres for the first support structure and a tank with a capacity less than or equal to 25 litres for the second support structure may be provided.

[0060] The control device 30 for controlling the flow of water from the liquid tank 25 to the nebulizing device 12 may be provided with an ON/OFF valve controlled by hand by an operator to stop the flow at high speed according to the decision of the operator on site, as required by the Machinery Directive 2006/42/EC. The control device 30 optionally comprises a control panel for starting and emergency safety stopping. An extinguishing foam tank may also be provided, with a suitable capacity, for example of one litre.

[0061] On the basis of the above description, it is easy to understand how the use of the water mist fire extinguishing apparatus 10 according to the invention may be carried out.

[0062] The use of a water mist fire extinguishing apparatus 10 according to the invention provides for an operator to transport the apparatus to the site of a fire during an initial stage, that is, close to the start of the fire, and to use the apparatus for a first attack on the fire, independently and autonomously. That is to say without connecting the water mist fire extinguishing apparatus 10 to an external supply source, whether it is water or electricity.

[0063] Preferably, the transport of the water mist fire extinguishing apparatus 10 is carried out manually by the operator.

[0064] In particular, the use of the water mist fire extinguishing apparatus 10 involves carrying all the components, preferably housed in the containment box 11, to the site of the start of the fire, and then opening the container or box; alternatively, all the components, preferably supported by the respective support structure(s), are carried to the site of the start of the fire.

[0065] Subsequently the pressure generator is activated and then the nebulizing device 20 opens. The nebulizing device 20 may already be joined to the second end of the tube 17, or associated as needed. As mentioned, known types

of valves and pushbutton systems may be provided to ensure the safe use of the water mist fire extinguishing apparatus 10.

[0066] Considering the volumes of water used, and thanks to the fact that a nebulization typical of water mist is created, all the typical characteristics for this technology are preserved. No electrical or electronic devices, furniture and valuables are damaged and no injuries are caused to people and animals accidentally struck by the jet, even at close range.

[0067] If it is a very early stage fire, the fire may be extinguished quickly using a minimum amount of water.

[0068] Furthermore, thanks to the water mist fire extinguishing apparatus according to the invention, the portable fire-fighting systems still in use containing powder, foaming materials or inert gases are replaced, and problems of intoxication or contamination of people and property involved in an attack on a fire are avoided.

[0069] The water mist fire extinguishing apparatus 10 is obviously an eco-friendly element that has absolutely no impact on soil, air and water, neither during the training of firefighters, nor during actual use, as it works effectively also with the use of just pure water.

[0070] Preferably, the water mist fire extinguishing apparatus 10 is configured to be able to be connected to an external water supply service to allow water to be fed for a longer time than the initial time indicated above. For this purpose, the water mist fire extinguishing apparatus 10 includes a quick coupling device 35 for connecting the nebulizing device 20 to the water supply service, replacing the tank 25.

[0071] In this case, the use of a water mist fire extinguishing apparatus 10 requires, after the first attack on the fire, connection to an external water source.

[0072] The water mist fire extinguishing apparatus 10 may also be associated with a shockproof frame/support (not shown in the drawings) to contain the box 11 in a stable condition.

[0073] If the water mist fire extinguishing apparatus 10 has to be connected to a water supply service, the tube 17 may be detached from the tank 25 and, if necessary, once equipped with an extension, connected to the water supply service by means of the extension.

[0074] Alternatively, if the length of the pipe is not adequate, despite the addition of a suitable extension, the containment box 11 may be removed from the supporting frame, and positioned where there is access to a service water supply line with an adequate connection, and then the previous procedure repeated.

[0075] The invention also relates to a method for carrying out a first attack on the fire. This method provides for the preparation of a water mist fire extinguishing apparatus, having a total weight of less than or equal to 80 kg and configured to be transportable and functionally and temporally autonomous to attack the fire up to a maximum time of 300 sec. The method according to the invention further provides for the transport of this water mist fire extinguishing apparatus 10 by an operator to the site of the first attack on the fire in order to attack the fire. Preferably, the water mist fire extinguishing apparatus 10 is transported manually by an operator. Furthermore, according to the method of the invention, the first attack on the fire occurs autonomously, that is, without connecting the water mist fire extinguishing apparatus 10 to a water supply source or service. In other words, after having transported the water mist fire extinguishing apparatus 10 to the site of the first attack on the fire to attack the fire, the latter is activated in autonomous mode, that is, without connection to a water supply source or service. That is to say, during the first attack on the fire, the water mist fire extinguishing apparatus 10 is not connected to an external water supply source. Preferably, during the first attack on the fire, the water mist fire extinguishing apparatus 10 is also not connected to an external power supply source.

[0076] According to a preferred aspect of the above-mentioned method, the water mist fire extinguishing apparatus 10 includes the following components:

- an energy accumulator (18),
- a pressure generator (12),
- a nebulizing device (20),
- at least one tank (25) of liquid, configured to be connected to the pressure generator (12),
- a control device (30) for controlling the pressure generator (12) and
- a tube (17), wherein a first end of the tube (17) is connected to the pressure generator (12) and a second end is connected to the nebulizing device (20).

[0077] Furthermore, according to this preferred aspect, all the above-mentioned components are transported near or to the site of the fire, that is to say of the start of the fire. The pressure generator (12) is activated and the nebulizing device (20) is then opened to carry out a first attack on the fire.

[0078] In particular, according to a further preferred aspect, the method for autonomously carrying out a first attack on the fire by means of a water mist technology also provides for the following steps:

- preparing the following components: a liquid tank 25, preferably an aqueous solution, or plain water L, a tube 17, preferably a rubber hose, a pressure generator 12 connected to the tank and configured to pressurize the liquid towards a first end of the flexible tube, a nebulizing device 20 located at a second end of the flexible tube, an energy accumulator 18, and a control device 30 for controlling the pressure generator 12;

- bringing the above-mentioned components to the site of the initial fire, switching on the pressure generator 12 to pressurize the liquid in the tube 17 and allow the liquid to be nebulized through the nebulizing device, and directing the nebulized liquid towards the initial fire to carry out the first attack on the fire.

[0079] The method according to the invention also provides for the possibility that after the first attack on the fire, the water mist fire extinguishing apparatus 10 is connected to an external water source.

[0080] Preferably, according to the method of the invention, a water mist fire extinguishing apparatus 10 as described above is used.

[0081] This method simplifies the procedure of a typical fire fighting intervention for the following reasons.

[0082] The above-mentioned components, possibly supported by the respective support structure (s), may be easily transported to an internal space whether it be a house, a farm or a boat.

[0083] The components are sufficient to carry out the first attack on the fire very quickly, as it is a standalone apparatus. The use of two tanks may be envisaged for the attack on the fire.

[0084] The attack may last up to the time necessary to extinguish the fire and where a suitable water supply line with a very low flow rate is necessary and available (e.g. 10-20 l/min at 2-3 bar), the extinguishing may be assisted, at a later time, by supplying water from an external source.

[0085] According to a preferred aspect of the invention, in order to improve the nebulization capabilities of the nebulizing device 20 described above, the use of a specific nozzle 23 is proposed.

[0086] In particular, with reference to Figures 4-7, a nozzle 23 according to the invention is fed with the liquid under pressure and configured in such a way that the jet effluent from the nozzle 23 is a jet of nebulized liquid.

[0087] The nozzle 23, as explained in more detail below, is particularly suitable for use with the above-mentioned liquid L, preferably at high pressure or very high pressure. "High or very high pressure" means pressures even higher than 90 bar, preferably pressures between 90 and 500 bar.

[0088] The nozzle 23 comprises an inlet 2311, an outlet 2317 and a fluidic connection line 2310 extending between the inlet 2311 and the outlet 2317.

[0089] Essentially, the fluidic connection line 2310 preferably comprises in succession a duct 2312 and a duct 2314 fluidically connected by means of one or more openings 2313. Conveniently, the duct 2312 may have a substantially larger section than the annular crown 2314 in such a way that the speed of the water flow increases as it passes from the duct 2312 to the duct 2314. Subsequently, the fluidic connection line 2310 may comprise an operating chamber 2316 fluidically connected with the duct 2314 by means of one or more openings 2315.

[0090] Essentially, the ducts 2312, 2314, the operating chamber 2316 and the openings 2313, 2315 may therefore be mutually dimensioned, that is, they may have different and suitably sized passage sections, so that the water increases the speed in the duct 2314 and in the chamber 2316, with consequent pressure variations as the flow rate is substantially constant.

[0091] In particular, as described in more detail below, the openings 15 may be configured in such a way as to modify the direction and speed of the flow of water entering the operating chamber 2316 giving rise to a vortex-shaped trend.

[0092] In this way, by entering the operating chamber 2316, the water will be able to increase the speed and therefore create a turbulent motion inside it. This effect, as described in more detail below, may be favoured by the mutual configuration of the openings 15 and of the operating chamber 2316. Advantageously, inside the chamber 2316 the speed of the water flow may increase significantly. As is known, in this case the flow may pass from a situation of so-called laminar regime to a situation of so-called turbulent regime. In the literature it is known that this variation leads to an increase in the Reynolds number.

[0093] Under these conditions, a plurality of water vapour bubbles and a plurality of droplets of particularly small diameter may then be formed which may then flow from the operating chamber 2316 through an outlet or orifice 2317. Preferably, the operating chamber 2316 may comprise a single outlet opening 2317 which may define the outlet of the nozzle 23. In particular, all the water L may pass through the single opening 2317 with a consequent increase in speed.

[0094] The outlet 2317 may have a particularly small section considering the high or very high operating pressure of the system so that the single effluent jet has a particularly high outlet speed, and a particularly high number of small droplets.

[0095] For example, the opening 2317 may preferably be circular and may have a diameter of the order of 1-3 mm, preferably of about 1.2-2 mm. It is understood that the section of the opening 2317 may vary according to the flow rate and the pressure.The diameter of the opening 2317 as a function of flow rate and pressure is a value within the reach of a person skilled in the art.

[0096] Furthermore, as explained in more detail below, the particular configuration of the edge of the outlet 2317 will allow the breaking up of the jet and consequently theformation of a large number of micro-droplets.

[0097] According to a preferred but not exclusive embodiment of the invention, the nozzle 23 may comprise a main body having a substantially longitudinal extension along an X axis. Preferably, but not exclusively, the main body may have a substantially cylindrical shape. The main body may be made in two parts 2320, 2330. These parts 2320, 2330

may be mutually coupled in a removable way. For example, they may be mutually screwed in a per se known manner.

[0098] The part 2330 of the body may have a substantially cylindrical shape. In particular, it may internally comprise a substantially cylindrical hole 2332, preferably coaxial to the X axis.

[0099] The hole 2332 may include the opening 2311 and the openings 2313.

[0100] In particular, the hole 2332 may comprise an open bottom wall 321 which may define the inlet opening 2311, a closed opposite bottom wall 322 and one or a plurality of peripheral openings 2313 of the bottom wall 322. For example, these openings 2313 could be four equally spaced circular holes. In other words, the hole 2332 may define the duct 2312.

[0101] The body 2330 may comprise a substantially cylindrical portion 2333 and a portion 2334 also substantially cylindrical having an external diameter smaller than the external diameter of the portion 2333. In other words, an annular projection 342 may be provided between the two portions having a height h.

[0102] Conveniently, the openings 2313 may be in correspondence with the portion 2334. Furthermore, the portion 2334 may internally comprise a circular hole 2335 substantially coaxial to the X axis. This circular hole 2335 may comprise a plurality of peripheral openings 15, that is, placed in correspondence with the side wall of hole 2335. Preferably, the holes 2332 and 2335 may be substantially coaxial to the same X axis.

[0103] The portion 2334 may therefore comprise the openings 2315. Preferably, these openings 2315 may have a substantially longitudinal extension coaxial to the X axis. Optionally, the openings 2315 may extend in length substantially for the entire length of the side wall 351 of the hole 2335. More in detail, the side wall 351 of the hole 2335 may have a predetermined thickness. The openings 2315 may extend through the thickness of the wall 351 in a substantially radial manner, or they may be inclined with respect to the radius as illustrated in Fig. 5.

[0104] In this way, advantageously, the flow entering through the openings 2315 will be able to rotate inside the chamber 2316 around the X axis, that is, a vortex may be created around the X axis.

[0105] Furthermore, the openings 2315 may have a substantially constant section through the wall 351, or their section may shrink radially, that is, it may decrease along the wall 351 as it approaches the X axis. For example, the openings may have the known slot configuration.

[0106] The configuration of the openings 2315 will therefore allow both the speed and the direction of the flow of water entering the chamber 2316 to be modified so that the flow inside the chamber has a vortex-shaped trend. Preferably, these openings 2313 may be circular holes placed in proximity to the inside of the chamber having a vortex-shaped trend.

[0107] In other words, it will therefore be possible to further increase the turbulence in chamber 2316. Thanks to this feature, inside the chamber 2316 it will be possible to have a particularly turbulent motion which may therefore favour the formation of a large number of water vapour bubbles within the water flow.

[0108] As known in the literature, the higher the Reynolds number, the greater may be the turbulence inside the chamber. For example, such turbulent flow in the chamber may have a Reynolds number Re >4000. Furthermore, the more turbulent the flow, the greater the number of small droplets and therefore the degree of nebulization of the jet effluent from the nozzle 23. The body 2320 may comprise a substantially flat area 2321 which includes the outlet 2317.

[0109] In particular, once the body 2320 and the body 2330 have been coupled, the area 2321 may remain in correspondence with the hole 2335 so as to close the latter and define the operating chamber 2316. More in detail, the body 2320 may comprise a plate 2322 having a hole or opening 2323 defining the outlet 2317 and a front surface 2321 intended to interact with the portion 2334.

[0110] The plate 2322 may have a substantially discoidal shape and may have an external diameter substantially greater than the internal diameter of the hole 2335. In this way, once the body 2320 and the body 2330 are coupled, the plate 2322 may have an internal area 221 of the surface intended to close the hole 2335 and an external area 222 of the surface in abutment with the edge 352 of the side wall 351 of the hole 2335 so as to force the water L out through hole 2323.

[0111] The hole 2323 may preferably, but not exclusively, be central and coaxial to the X axis. For example, the central hole 2323 may have a circular shape or may have different shapes according to requirements, for example it may have an elliptical shape. According to a particular aspect of the invention, the hole 2323 may have a constant section.

[0112] Preferably, the hole 2323 may have a sharp edge 235 which may define the edge of opening 2317. In other words, the angle between the lateral surface 231 and the internal area 221 of the surface of the plate 2322 may be substantially right-angled. For example, the plate 2322 may have a predetermined thickness, and the hole 2323 may have a substantially cylindrical shape. In other words, the hole 2323 may have a substantially cylindrical lateral surface 231 parallel to the X axis. On the other hand, if the hole 2323 has different shapes, for example elliptical, the lateral surface 231 may in any case be parallel to the X axis.

[0113] Advantageously, the flow of water L may encounter high resistances, may have a low efficiency and a high degree of nebulization of the effluent jet (as indicated in the experiment below).

[0114] In fact, thanks to the typology of the channels inside the jet and the geometry of the outlet path, the flow of water L coming out of the nozzle 23 will be able to have a high nebulizing rate.

[0115] The effluent jet, therefore, will be able to satisfy the nebulization characteristics of the jet of class 1 of the American fire prevention standard NFPA-750. In other words, the water mist fire extinguishing apparatus 10 with the

nozzle 23 may have a jet in which at a distance of 1 m from the nozzle at least 10% of the droplets have an average diameter of <100 μm and 90% have an average diameter of <200 μm (class 1 NFPA 750 US).

[0116] Preferably, at a distance of 1 metre from the nozzle 23, the nebulized jet emerging from the nozzle 23 may have about 30% of droplets with an average diameter of less than 50 μm and about 45% with an average diameter of between 50 μm and 100 μm.

[0117] On the other hand, the nebulized jet emerging from the nozzle 23 may have an average droplet diameter of less than 30 μm, preferably of about 10 μm - 30 μm. The nebulized jet effluent from the nozzle 23 may have a flow rate of 5 - 100 l/min, preferably of 6 - 80 l/min, even more preferably of about 6-12 l/min.

[0118] The effluent jet flow from the nozzle 23 may have an output speed of 130 m/s - 300 m/s with working pressures varying between 90 and 500 bar.

[0119] Conveniently, the plate 2322 may be made of a particularly hard material. This material may comprise or consist of particular forms of aluminium oxides, for example of corundum (ruby or sapphire), or of diamond.

[0120] Preferably, the material of the plate 2322 may have a hardness according to the Mohs scale equal to 8 or higher, preferably equal to 9 or higher.

[0121] This material may be natural or it may be made synthetically. It is understood that such examples of materials described above are not exclusive. For example, it is possible to use other known materials having a high hardness and resistance to abrasion. Conveniently, the plate 2322 may comprise a base matrix and powder of such hard material, for example diamond.

[0122] The plate 2322 may also be treated with this material only on the surface or a layer of such hard material may be provided, placed in proximity to the surface 221 of the plate 2322. On the other hand, the plate 2322 may be entirely made of this material, for example the plate 2322 may be made of synthetic ruby, synthetic sapphire or other synthetic material with a hardness greater than 8 Mohs.

[0123] In any case, the plate 2322 or the parts thereof intended to come into contact with the water may be made with this material.

[0124] Thanks to these characteristics, the plate 2322 will be able to resist the action of water L and will be able to guarantee a high durability of the nozzle 23. Furthermore, wear of the edge 235 may be avoided so that the nozzle 23 maintains a high nebulization efficiency over time.

[0125] The body 2320 may further comprise an area 2325 having an internal surface 251 intended to remain facing the external surface 341 of the portion 2334 of the body 2330 and spaced from the latter so as to define an interspace. More in detail, the annular projection 342, the flat area 2321, the external surface 341 and the internal surface 251 may define the interspace 2314.

[0126] The height h of the projection 342 may define the width of the interspace. In other words, the internal surface 251 may have the same shape as the external surface 341 and may be spaced by the distance h. Optionally, the distance h may be defined by the unloading of the coupling thread of the bodies 2320 and 2330.

[0127] Preferably, the internal surface 251 and the external surface 341 may be cylindrical and coaxial to the X axis. This interspace may define the duct 2314. The openings 2313 and the openings 2315 may therefore be mutually spaced so as to put the duct 2314 in fluid communication with, respectively, the hole 2332 and therefore the duct 2312 and with the hole 2335 and therefore the operating chamber 2316.

[0128] The openings 2313 and 2315 may therefore define respectively the inlet and outlet of the duct 2314.

[0129] Conveniently, the duct 2312 may have a substantially larger section than the duct 2314 in such a way that the flow of water has a higher speed in the duct 2314 than in the duct 2312.

[0130] Advantageously, the nozzle 23 may have a single opening 2317 and the entire nebulized jet flows from this opening or orifice at high speed. Despite the particularly high speed, thanks to the particularly small diameter of the droplets, and therefore to their extremely small mass, the momentum may therefore be relatively low.

[0131] In this way the effluent jet will not be harmful if it strikes during use against objects or operators.

[0132] The nozzle 23 and the water mist fire extinguishing apparatus 10 may therefore be particularly safe and free from damage induced by the high-pressure jet.

[0133] According to an alternative embodiment, the nozzle 23 may be snap coupled to the lance 22. In this way the assembly and disassembly operations may be particularly simple and fast.

Experiment

[0134] An experiment aimed at measuring the nebulization effectiveness of the nozzle 23 with respect to a known nozzle is reported below.

[0135] This experiment uses the well-known laser anemometry technique called Phase Doppler, which, in a chosen point of collimation of two laser beams, allows droplet diameters of between 0.5 μm and a few mm to be analysed, in order to define the following parameters: number of droplets in transit, diameter and speed.

[0136] This experiment was carried out considering a same high pressure system with a lance 22 on which a known

type of multi-hole nebulizer nozzle and subsequently the nozzle 23 according to the invention were mounted.

[0137] These measurements were taken 1 metre away from the nozzle of the lance (as per NFPA 750 standard). The graphs shown in Fig. 8 relate to the known nozzle, while the graphs shown in Fig. 9 relate to the nozzle 23 according to the invention. In both cases the speed readings are taken at a distance of 100 cm from the orifice or outlet opening of the water jet.

[0138] Some data extrapolated from these graphs are schematically shown below Table 1 below.

Table 1

	Droplet diameter $d \leq 50\mu m$	Droplet diameter $50 \leq d \leq 100\mu m$	Speed (U = m/s)
Known nozzle	15%	54.0%	6 - 60 m / s
Nozzle 23	27%	46.5%	4 - 18 m/s

[0139] These data show both the high nebulization efficiency of the nozzle 23 (high number of droplets with a reduced diameter) and the substantial performance improvements of the nozzle 23 compared to the known nozzle.

[0140] In particular, the percentage of droplets produced by the jet of the nozzle 23 with a diameter $d \leq 50\mu m$ is significantly higher than that of the known nozzle.

[0141] The effluent jet from the nozzle 23 therefore has a large number of droplets of reduced size, that is, the nozzle 23 nebulizes the jet of water better than the known nozzle.

[0142] Furthermore, the speed of the droplets of the nozzle 23 (4-18 m/s) is lower than that of the known nozzle (6-60 m/s) and the dispersion of the detected speed values of the jet effluent from the nozzle 23 is lower than the dispersion of the known nozzle velocity values. The friction with the air (drag force) represents the main force that prevents the advancement of a jet of nebulized water in the air, and this friction increases as the size of the droplets decreases.

[0143] For this reason, a lower speed is therefore a consequence of a greater friction.

[0144] Since the friction in air of the jet coming from the nozzle 23 is greater than that of the known nozzle, the droplets of the nozzle 23 are more dispersed and smaller than those of the known nozzle. Furthermore, since the jet values of the nozzle 23 are less dispersed than those of the known nozzle, the diameters of the droplets jet of the nozzle 23 have a greater uniformity than the diameters of the jet of the known nozzle. The jet of the nozzle 23 is therefore particularly widespread and has a large number of small diameter droplets, that is, it has a high degree of nebulization and therefore a high fire extinguishing efficiency due, as known, to the high heat exchange surface. The invention has thus far been described with reference to its preferred embodiments. It is to be understood that there may be other embodiments pertaining to the same inventive core, all falling within the scope of protection of the claims set forth below.

Claims

1. Water mist fire extinguishing apparatus (10) wherein the water mist fire extinguishing apparatus (10) has a total weight of less than or equal to 80 kg and is configured to be functionally and temporally autonomous to attack the fire for up to a maximum time of 300 sec, and wherein said water mist fire extinguishing apparatus (10) is transportable by an operator, and wherein the water mist fire extinguishing apparatus (10) includes the following components:

   an energy accumulator (18),
   a pressure generator (12),
   a nebulizing device (20),
   a liquid tank (25), configured to be connected to the pressure generator (12),
   a control device (30) for controlling the pressure generator (12) and
   a tube (17) having a first end configured to be connected to the pressure generator (12) and a second end configured to be connected to the nebulizing device (20).

2. The water mist fire extinguishing apparatus (10) according to claim 1, wherein said water mist fire extinguishing apparatus (10) does not require external sources to be able to function and wherein said water mist fire extinguishing apparatus (10) has reduced overall dimensions, that is to say, a volume less than 400mm X 600mm X 800mm, more preferably, the overall dimensions or volume is less than 350mm X 550mm X 750mm, and even more preferably less than 300mm X 520mm X 700 and yet even more preferably less than or equal to 290mm X 520mm X 650mm.

3. The water mist fire extinguishing apparatus (10) according to claim 1 or 2, wherein the water mist fire extinguishing apparatus (10) includes at least one support structure for supporting said components, or some of said components.

4. The water mist fire extinguishing apparatus (10) according to claim 3, wherein the support structure is a container body or a containment box (11).

5. The water mist fire extinguishing apparatus (10) according to claim 4, wherein said containment box (1) is shaped like a suitcase, preferably with a gripping element (21).

6. The water mist fire extinguishing apparatus (10) according to any one of claims 3 to 5, wherein said support structure is a first support structure and said water mist fire extinguishing apparatus (10) includes a second support structure wherein said second support structure supports at least said tank (25).

7. The water mist fire extinguishing apparatus (10) according to claim 6, wherein said tank is a first tank, and said water mist fire extinguishing apparatus (10) includes a second tank supported by said first support structure.

8. The water mist fire extinguishing apparatus (10) according to any one of the preceding claims, wherein said water mist fire extinguishing apparatus (10) has a total weight between about 70 kg and 30 kg, preferably between 55 kg and 35 kg, and even more preferably less than 50 kg.

9. The water mist fire extinguishing apparatus (10) according to any one of the preceding claims, wherein said water mist fire extinguishing apparatus (10) is configured to be functionally and temporally autonomous to attack the fire for a maximum time of between 300 sec. and 15 sec., preferably between 300 sec. and 45 sec., preferably between 240 sec. and 50 sec., still more preferably 180 sec. and 60 sec., for example for about 120 sec.

10. The water mist fire extinguishing apparatus (10) according to any one of the preceding claims, wherein the nebulizing device (20) includes a nozzle (23).

11. A use of a water mist fire extinguishing apparatus (10) according to any one of the preceding claims, wherein the water mist fire extinguishing apparatus (10) is transported by an operator to the site of a fire during an initial stage, and used for a first attack on the fire in an independent and autonomous manner.

12. The use according to claim 11, wherein after the first fire attack the water mist fire extinguishing apparatus (10) is connected to an external water source.

13. A method for carrying out a first attack on the fire, wherein the method provides for the setting up of a water mist fire extinguishing apparatus (10) having a total weight of less than 80 kg and configured to be functionally and temporally autonomous for a maximum time of up to 300 sec. and for the transporting of the water mist fire extinguishing apparatus (10) by an operator to the site of a first attack on the fire to attack the fire and activate the water mist fire extinguishing apparatus (10) in an autonomous manner to carry out a first attack on the fire and wherein the water mist fire extinguishing apparatus (10) includes the following components:

    an energy accumulator (18),
    a pressure generator (12),
    a nebulizing device (20),
    at least one tank (25) of liquid, configured to be connected to the pressure generator (12),
    a control device (30) for controlling the pressure generator (12) and
    a tube (17), wherein a first end of the tube (17) is connected to the pressure generator (12) and a second end is connected to the nebulizing device (20),
    and wherein said components are brought near or to the site of the fire and the pressure generator (12) is activated and then the nebulizing device (20) is opened to carry out a first attack on the fire.

14. The method according to claim 13, wherein after the first fire attack, the water mist fire extinguishing apparatus (10) is connected to an external water source.

15. The method according to any one of claims 13 to 14, wherein the water mist fire extinguishing apparatus (10) is the device according to any one of claims 1 to 10.

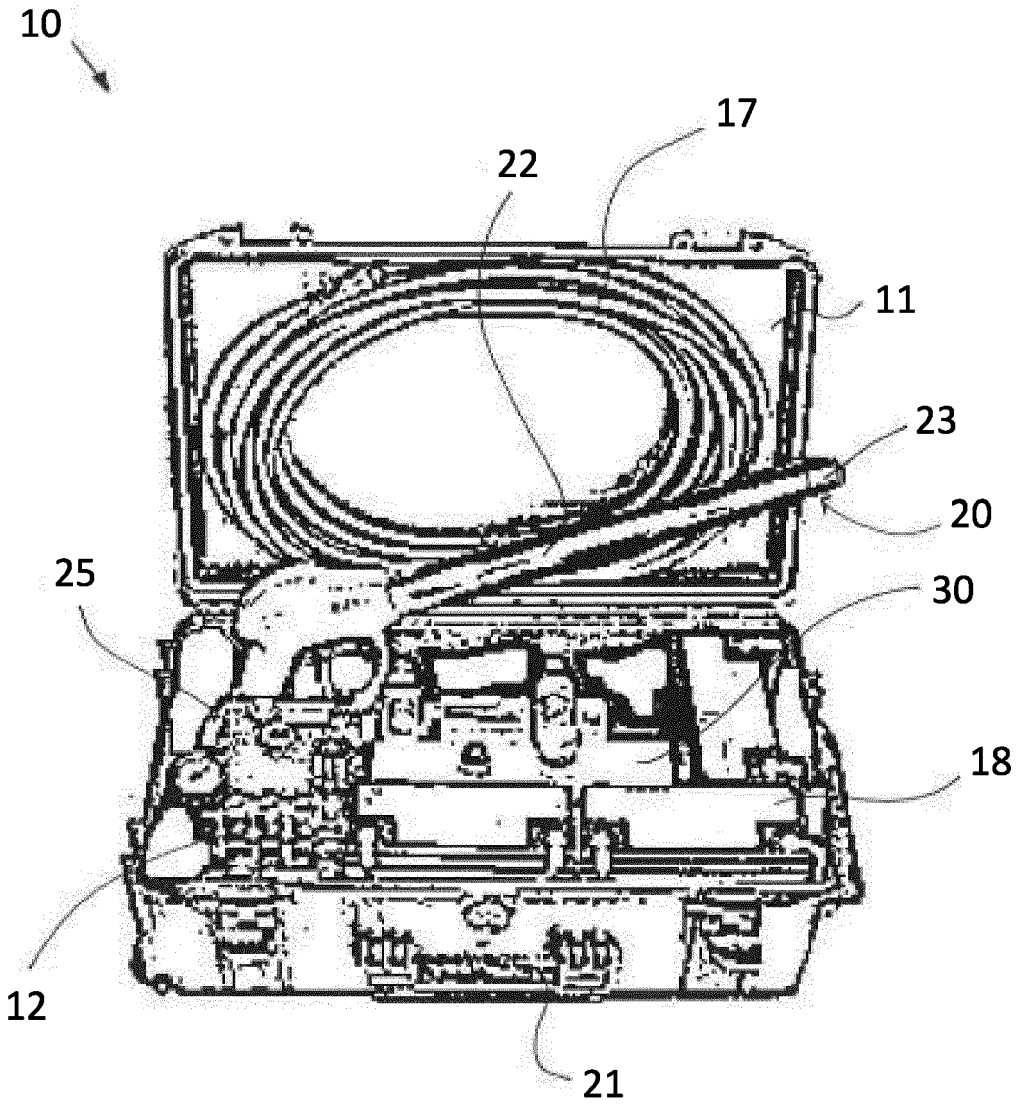


FIG. 1

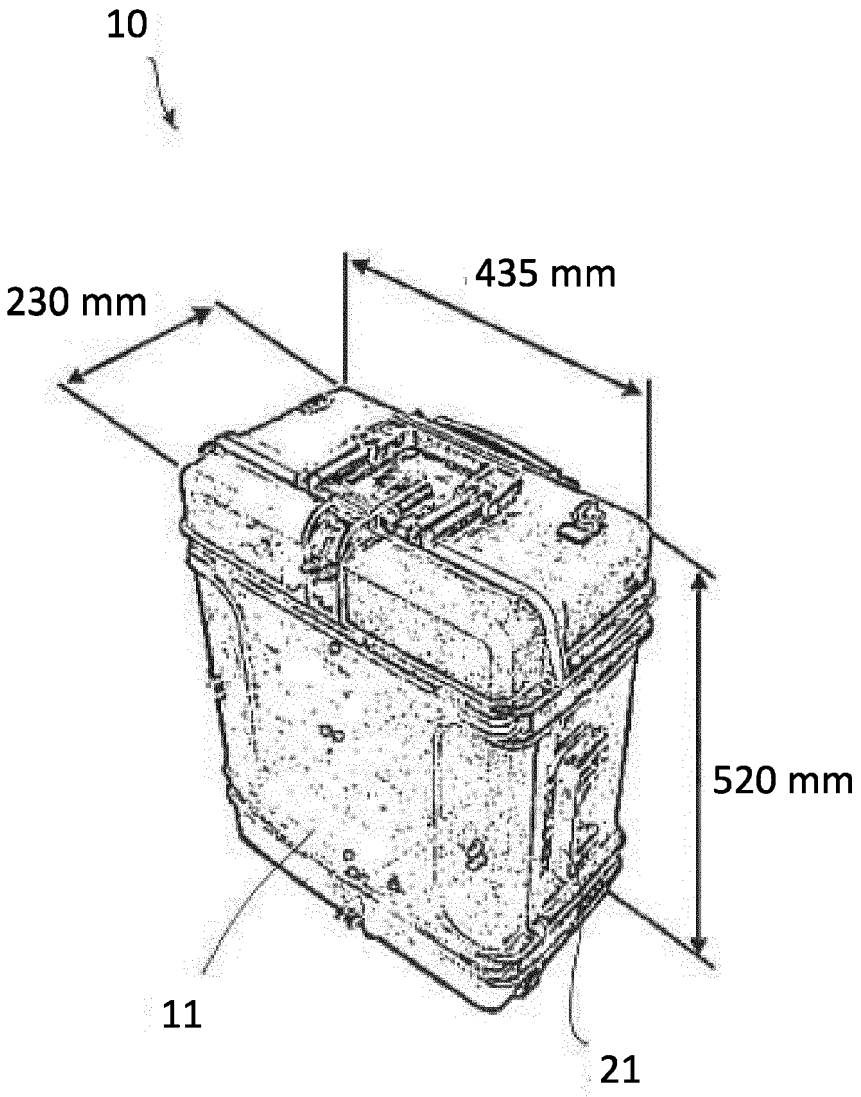


FIG. 2

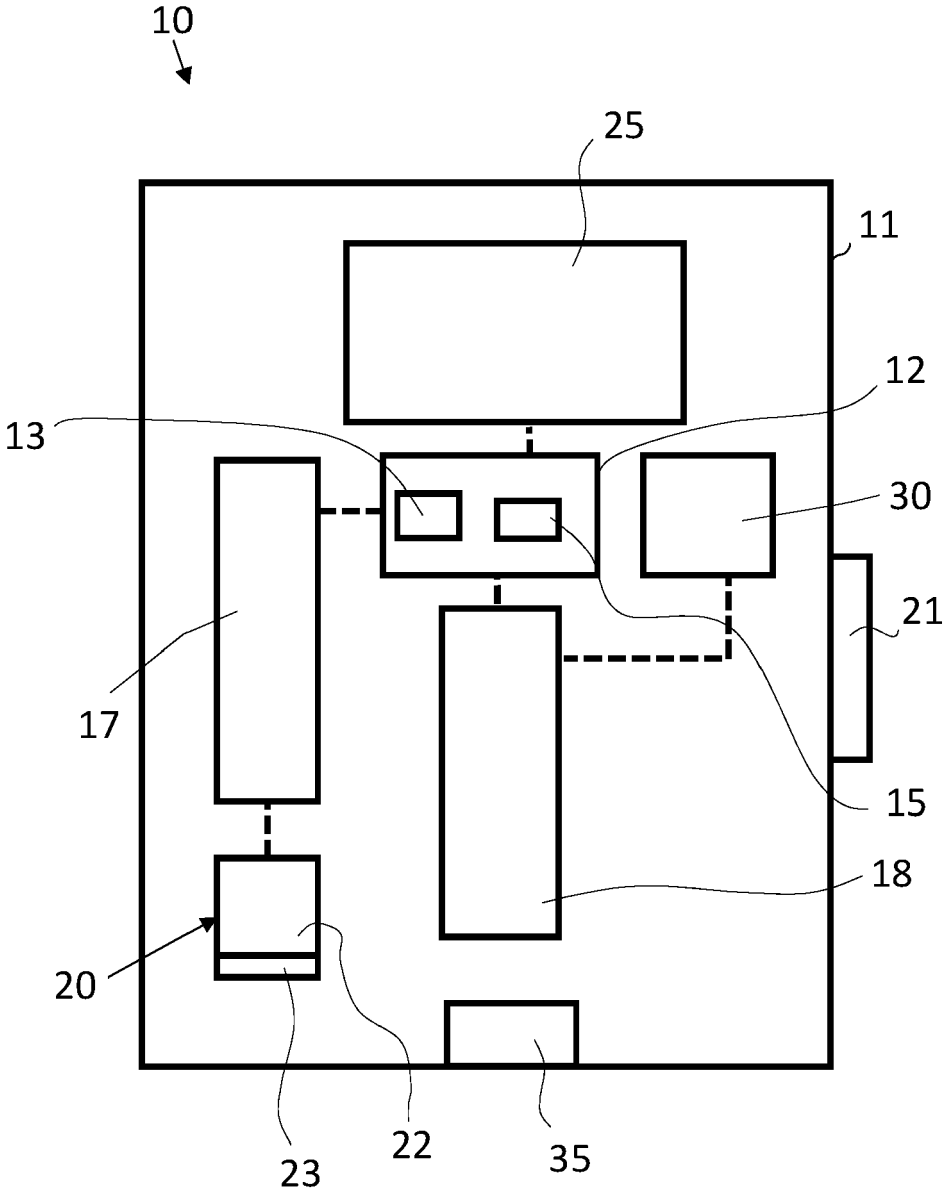


FIG. 3

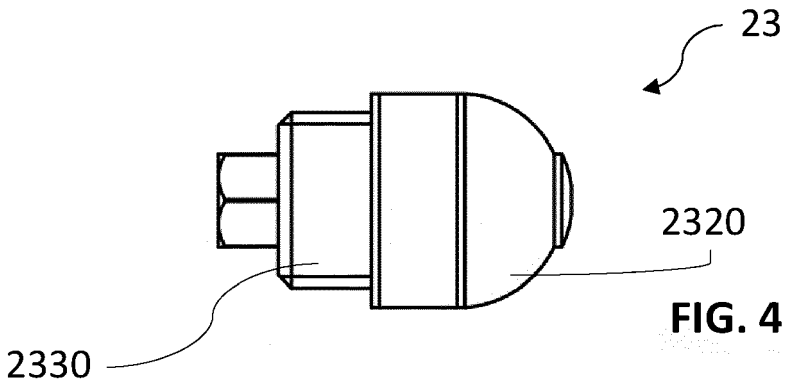
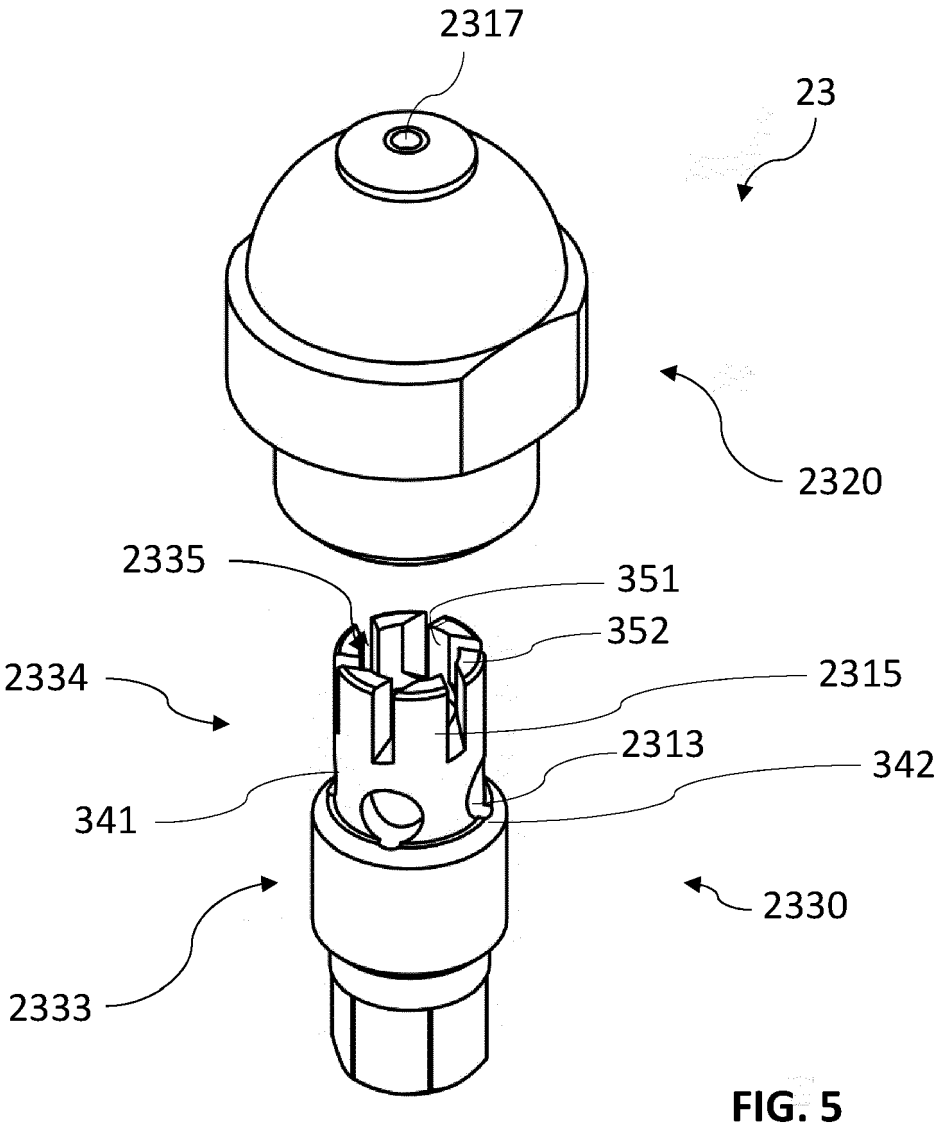

23
2320
2330

FIG. 4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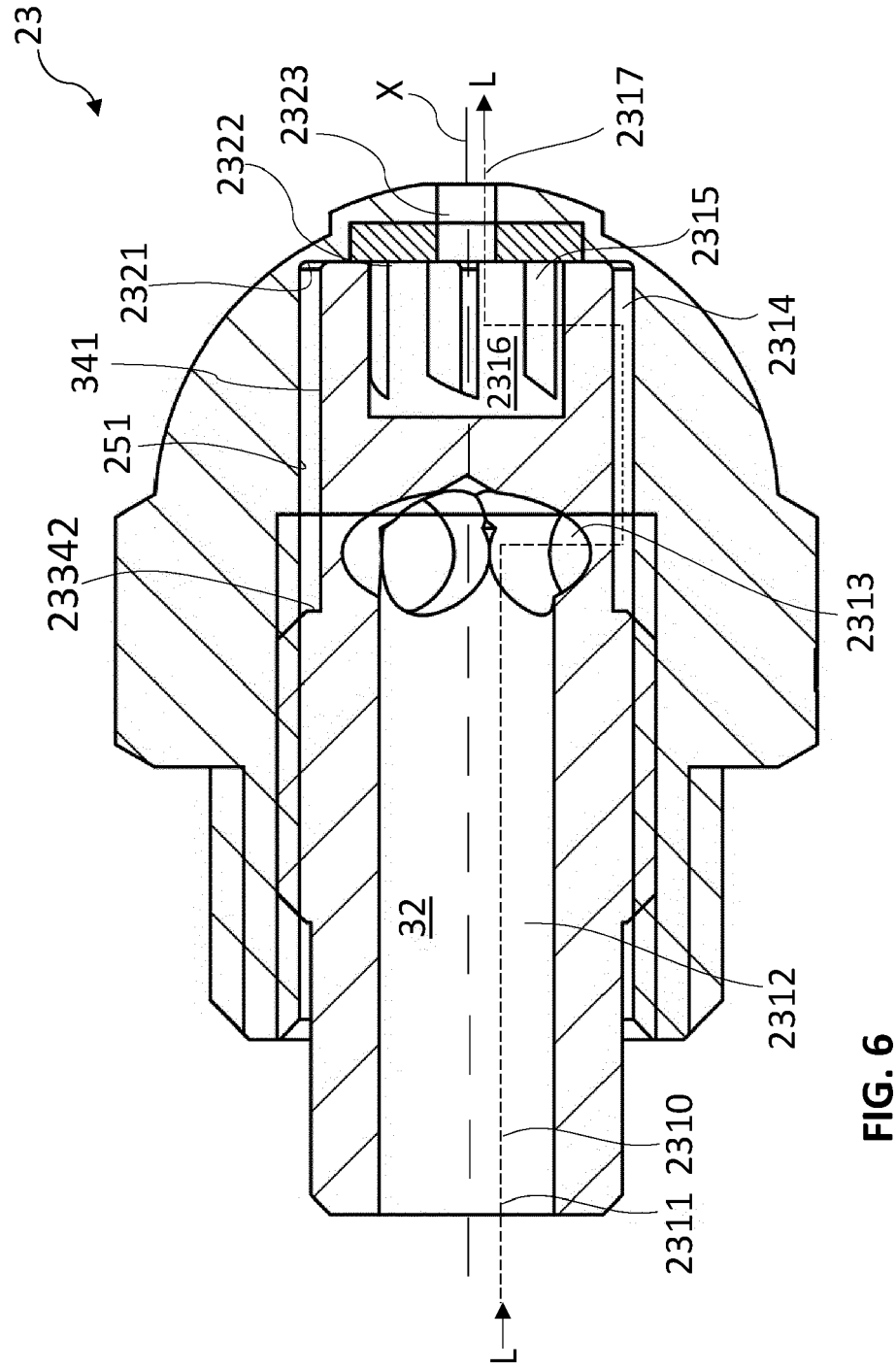
2333

FIG. 5


23
2323
X
L
2317
2322
2315
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251
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2313
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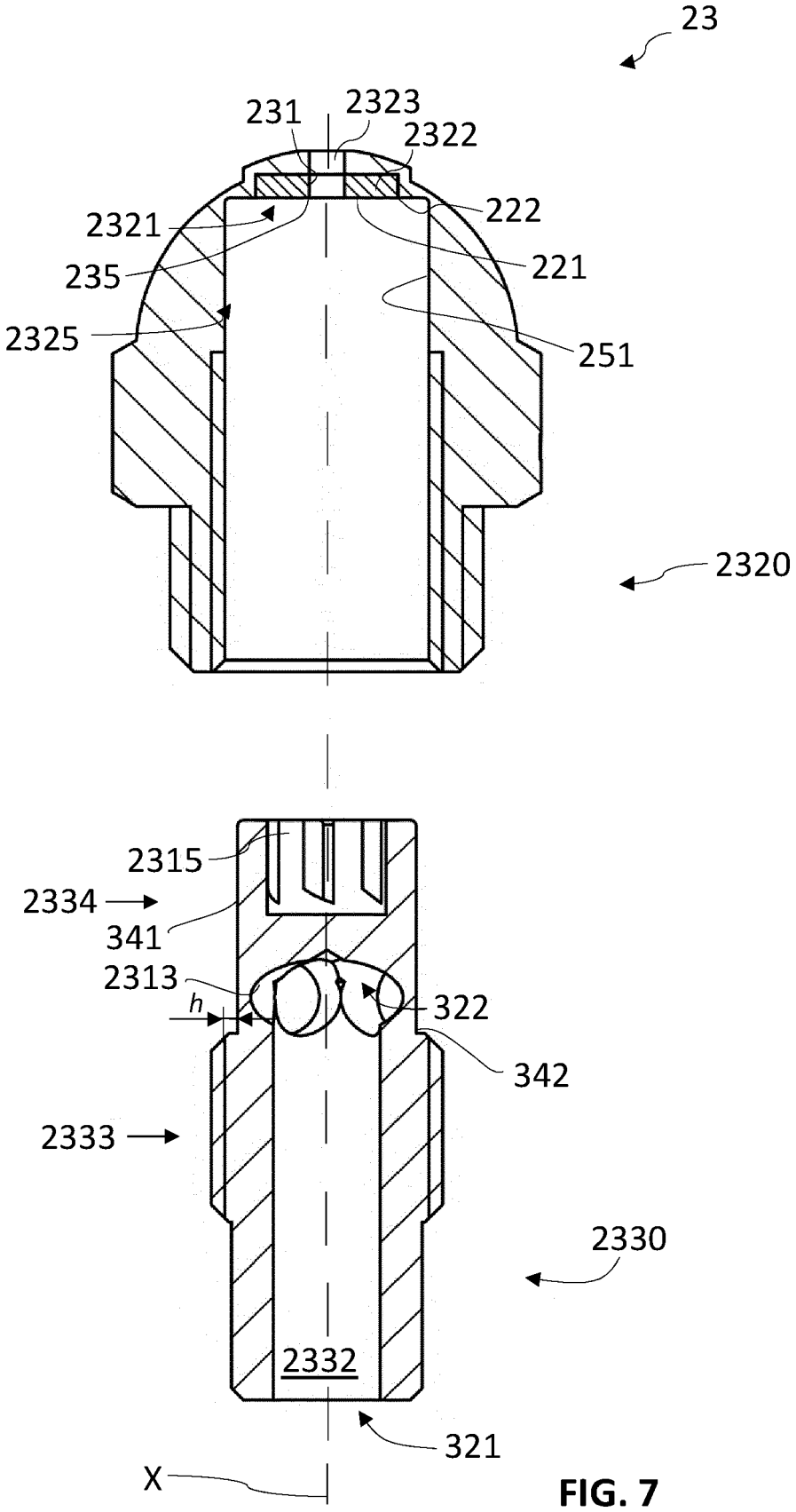
2312
2311 2310
L

FIG. 6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2332
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X

FIG. 7

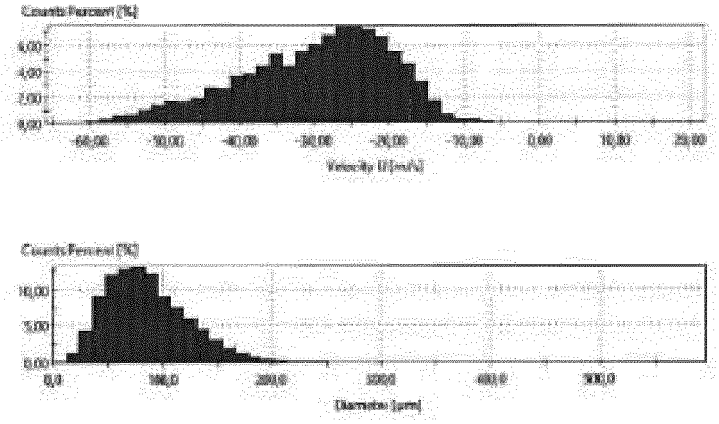

FIG. 8

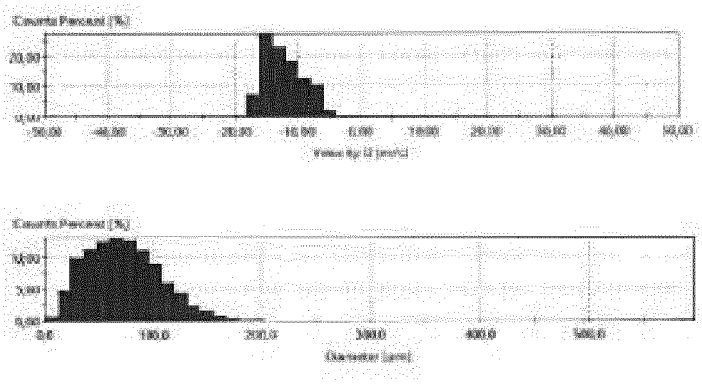

FIG. 9

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 2315

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2020/082013 A1 (PYROLANCE LLC [US]) 23 April 2020 (2020-04-23) * figures 1-12 * * figures 2, 8 * * figures 1, 3-7, 9-12 * * paragraphs [0034], [0058] *	1-8, 11-14	INV. A62C25/00 A62C99/00 A62C15/00
X	CN 105 521 575 A (ZHONGDAYUAN ELECTROMECHANICAL TECH CO LTD) 27 April 2016 (2016-04-27) * figures * * the whole document *	1-15	
X	KR 2014 0000397 U (DAESUNG HITECH CO LTD) 17 January 2014 (2014-01-17) * figures * * paragraph [0025] - paragraph [0032] *	1-15	
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			A62C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	16 August 2022	Cardin, Aurélie

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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L : document cited for other reasons

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 16 2315

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16-08-2022

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82