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(54) **A BARRIER FOR ENCAPSULATING A LIQUID MEDIUM WITHIN THE PERIMETER OF A VEHICLE, A SYSTEM FOR EXTINGUISHING A FIRE IN A BURNING VEHICLE OR AN ELECTRIC VEHICLE WITH AN OVERHEATED BATTERY AND A METHOD FOR EXTINGUISHING A FIRE IN A VEHICLE**

(57) The present invention relates to a barrier for encapsulating a liquid medium within the perimeter of a vehicle, a system for extinguishing a fire in a burning vehicle or an electric vehicle with an overheated battery and a method for extinguishing a fire in a vehicle.

The barrier comprises a main part having a circumferential chamber having a first volume defining an opening for surrounding the vehicle, having a first volume, and the barrier comprises an integrated channel having a second volume being smaller than the first volume, such that when injecting a fluid into the channels, the barrier unrolls or unfolds in the direction of the channels into a second state where the circumferential chamber surrounds the car.

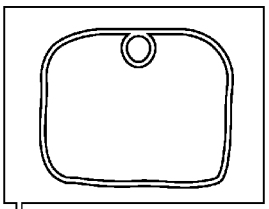

FIG. 4D

FIG. 4C

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Description

TECHNICAL FIELD

[0001] The present invention relates to a barrier for encapsulating a liquid medium within the perimeter of a vehicle, a system for extinguishing a fire in a burning vehicle or an electric vehicle with an overheated battery and a method for extinguishing a fire in a vehicle.

BACKGROUND OF THE INVENTION

[0002] During the recent years, the number of electric vehicles (EV's) has increased significantly e.g. due to the environmental impact of the electric cars on the environment, compared to fuel consuming cars.

[0003] Lithium-ion batteries, such as the ones used in EV's or electronic devices, may catch fire or overheat if they have manufacturing errors, have been damaged, or the controlling and/or monitoring of the battery is not functioning correctly.

[0004] EV batteries run at high voltage, typically between 400v and 800v, where 800v will probably become the norm in the future.

[0005] An EV battery catching fire, due to the above defined issues, or any other causes, looks like a spontaneous combustion, e.g. like in fuel consumption vehicles. However, the internal burning process within the battery is called a "thermal runaway" and is different from a normal burning process.

[0006] Unlike a fire in a fuel consuming vehicle where just one single reaction occurs, a fire in an EV battery comprises multiple steps. Essentially, an uncontrolled, cascading loop of violent chemical reactions releases a tremendous amount of energy and heat, and as the individual battery cells warm up, energy and heat drives through the rest of the battery in a kind of domino effect.

[0007] What makes this worse is the fact that, as the thermal runaway accelerates, the burning battery's stored energy essentially creates its own fuel (oxides). It's a chemical fire which doesn't necessarily need oxygen, hereby making it far harder to extinguish than a petrol fire. With the oxides present in the battery cells, temperatures from approx.

[0008] 180° C causes oxygen to be released in the battery, which reacts with cell components, in particular the electrolyte, which again leads to an exothermic reaction that cannot be stopped in practice, during which the battery burns.

[0009] The fires emit combustible and harmful gases such as hydrogen fluoride, and thanks to its internal thermal runaway the fire will not burn out.

[0010] A burning battery or an overheated battery in a parking environment, such as ferries, parking garages, underground parking, parking lots, tunnels etc. which might catch fire, provides a severe risk of human injury, and especially if the parking environment is a ferry, it provides a risk of the entire ship catching fire and thus resulting in a disaster.

[0011] Prior art systems propose internal sprinkler systems within the vehicle, or batteries which are arranged in an insulated container within the vehicle.

[0012] However, the process of installing an individual sprinkler system inside a vehicle is costly and almost impossible as the available room in a vehicle for such a system is very limited, and further, such systems deliver a very limited amount of fire extinguishing material. Further, as described above, as the burning batteries creates their own oxygen, the burning process continues for a long time, whereby an insulated container eventually would be melted or damaged. The fire would spread to the rest of the vehicle and eventually to the surroundings of the vehicle.

[0013] Further, when trying to extinguish fires having such continuing burning processes, large amounts of water need to be used, which may cause water damages to the surroundings of the car and increases the demands of the fire extinguishing system.

[0014] It is an object of the present invention to arrange a barrier, a system and a method for extinguishing a fire in a vehicle in which the above-defined drawbacks are avoided.

[0015] In particular, it is a first object of the invention to arrange a barrier, for use when extinguishing a fire in a vehicle, which eliminates the need for huge amounts of water.

[0016] It is a second object of the invention to arrange a system which can be arranged outside a burning vehicle, which is able to provide a fire extinguishing material to a burning or overheated EV battery and/or burning vehicle in an effective manner and which limits the amount of needed fire extinguishing medium.

[0017] It is a third object of the invention to provide a method for extinguishing and/or cooling down a battery in an EV, where a cooling medium is injected into the vehicle, and a burning vehicle battery or an overheated battery may effectively be extinguished and/or cooled down, such that the vehicle no longer poses a risk or the vehicle can be removed from the parking area without causing further damage to the surroundings and which limits the amount of needed fire extinguishing medium.

[0018] The above objects and advantages, together with numerous other objects and advantages, which will be evident from the description of the present invention, are according to a first aspect of the present invention obtained by:

A barrier for encapsulating a liquid medium, such as a fire extinguishing medium within the perimeter of a vehicle, such as a burning vehicle or an electric vehicle with an overheated battery,

- the barrier comprising a main part having a circumferential chamber defining an opening for surrounding the vehicle,
- the circumferential chamber having a first volume, and

- the barrier comprising an integrated channel having a second volume being smaller than the first volume,
- the volume of the channel being in fluid connection with an outside of the barrier, such that a fluid, such as water, may be injected into the channel,
- the barrier being configured to be arranged in a collapsed state, such as a rolled-up or folded state in a direction substantially perpendicular to the channels, such that when injecting a fluid into the channels, the barrier unrolls or unfolds in the direction of the channels into a second state where the circumferential chamber may surround the car.

[0019] The barrier is manufactured with a substantially ring-shaped and flexible main part having an opening, such that the barrier can be arranged circumventing a car. The main part has a chamber with a volume, such that the barrier, when being filled with a fluid such as water, or a gas/air such as co2, or any other air or gas type., has a diameter which substantially at least corresponds to an estimated height of an EV battery in relation to the ground surface. The chamber may in one example have a diameter of approximate Ø45 cm and the channel may have a diameter of approximate Ø5cm. It is obvious that the diameters may be arranged differently according to the estimated dimensions of the barrier and the target vehicle.

[0020] The limited dimension and flexibility of the barrier, compared to larger barriers, e.g. barriers having a height corresponding to the height of the car, provides the possibility of rolling or folding the barrier into a compact state, where the barrier can be stored, and in the event of a fire or an overheated EV-battery the barrier can easily be placed on top of the vehicle for deployment.

[0021] In order to deploy and unroll/unfold the barrier, a channel, such as a flexible tube is arranged integrated with the main part. The channel may be arranged connected to the main part on the exterior thereof or may be arranged integrated within the chamber and communicating with the outside of the main part, such that a fluid, e.g. water, or a gas or air type can be injected into the channel from the outside.

[0022] The channel has a smaller volume and diameter to the chamber sufficient to unfold/unroll the bigger chamber, such that during injection of a fluid or gas/air into the channel, the rolled-up or folded channel starts to unroll/unfold which forces the main part to unroll/unfold. The diameter and volume of the channel may be smaller or larger, depending the volume of the chamber and depending on the source of fluid/air/gas. The smaller volume of the channel ensures that the channel is rapidly filled, and pressurized, which forces the main part to unroll/unfold. The barrier which is preferably placed sideways across the roof of the car, automatically drops down around the car when being filled.

[0023] After the barrier has unrolled/unfolded around the car, the chamber of the main part can be completely filled, preferably with water, such that the barrier is erected in full and into the second state. When the barrier is completely erected, the chamber is filled with a fluid, e.g. water, such that the mass of the barrier prevents any significant amount of fire extinguishing medium which is injected into the car from escaping out from under the barrier.

[0024] Where the channel is filled with water, the channel is preferably arranged in fluid connection with the chamber of the main part, such that when the channel is filled, water runs out of the channel and into the chamber, hereby filling the chamber. It is also possible to arrange the volume channel and chamber separate from one another. In such situation, the chamber must be connected to a water source for filling.

[0025] Where the channel is filled with air/gas, it is preferred that the channel is not in fluid communication with the chamber. The barrier comprises means such as a coupling, for injecting fluid, such as water, directly into the chamber, after or simultaneously with the channel is being filled with air/gas.

[0026] According to a further embodiment of the first aspect of the invention, the barrier comprising an elongated shape.

[0027] The barrier is preferably arranged elongated, having a longitudinal and a latitudinal dimension. When rolling/folding the barrier in the longitudinal direction, the barrier requires minimum space and is easy to handle.

[0028] The barrier may be rectangular elongated and having two longitudinal sides and two latitudinal sides. The barrier may however have other shapes such as a oval shape where that parts having the largest curvature defines the longitudinal dimension and the parts having the smallest curvature defines the latitudinal dimension.

[0029] According to a further embodiment of the first aspect of the invention, the barrier in the first state being rolled up or folded from opposite ends respectively and towards a center of said barrier.

[0030] In order to rapidly unroll/unfold the barrier, the barrier is rolled up or folded in the longitudinal direction from opposite ends and toward the center of the barrier, hereby arranging a double roll/fold.

[0031] According to a further embodiment of the first aspect of the invention, the channel comprising an inlet at a position on said barrier where said opening has a diameter smaller than the largest diameter of said opening.

[0032] The inlet into the channel is preferably located toward the center of the barrier in the longitudinal direction, and most preferably at the center, such that the channel extends from the inlet and toward the longitudinal ends of the barrier. Hereby each side of the channel in connection with the inlet is subjected to substantially the same water/air/gas pressure and the opposing rolls/folds of the barrier unrolls/unfolds simultaneously which ensures correct deployment of the barrier.

[0033] According to a further embodiment of the first aspect of the invention, the barrier comprises two channels extending in a longitudinal direction of the barrier at

opposite sides of said barrier.

[0034] The barrier preferably comprises two channels, extending along opposite sides of the barrier in the longitudinal direction. Arranging a channel on each longitudinal side, ensures that the barrier unrolls/unfolds and deploys correctly around the car.

[0035] According to a further embodiment of the first aspect of the invention, the channels extending in the first longitudinal direction and in a second latitudinal direction of said barrier.

[0036] The barrier may further be arranged such that the channels extend in the longitudinal direction and continues in the latitudinal direction of the barrier at one or both ends thereof.

[0037] Each channel preferably terminates toward the center of the latitudinal sides of the barrier. Arranging the channels in both the longitudinal and latitudinal direction ensures that the shape of the barrier can be maintained unrolled/unfolded in both directions, and ensures that the barrier gets its full final shape.

[0038] According to a further embodiment of the first aspect of the invention, the barrier comprises an injection tube, where one end of the injection tube being connected to the channel, and the other end of said injection tube communicating with an injection system arranged outside of the barrier.

[0039] The barrier is in a preferred embodiment arranged with an injection tube, such as a flexible hose, exterior of the main part and connected to the channel for injecting water/air/gas into the channel. One end of the injection tube is thus connected to the channel and the other end connected to the source. The injection tube may be integrated with the channel or may be connected thereto by suitable connection means such as couplings known in the art.

[0040] The injection tube may branch off before the junction with the channel, into a second injection channel, which extends from the first injection tube to the channel arranged on/in the opposite side of the barrier.

[0041] It is hereby achieved that the injection channels only require one source of fluid, such as water or air/gas and still being able to fill the channels of opposite sides of the barrier at the same time.

[0042] Another option is to have one water filling on each side, or to have e.g., a bottle for gas injection into smaller tube on each side.

[0043] According to a further embodiment of the first aspect of the invention, the channel and/or the injection tube comprising a valve, such as a one-way valve.

[0044] It is preferred that the injection tubes and/or channels comprise a valve respectively, such as a one-way valve to ensure that water may flow through the channels and into the barrier chamber, but in the event that the injection tubes get damaged during or after deployment, e.g. from the fire, the water will not flow from the barrier chamber and out through the injection tubes. Therefore, a mechanically one-way valve may be arranged inside the injection tubes or the channels, respectively.

[0045] Alternatively, the ends of the channels are arranged "loose" within the barrier chamber, which gives the channel ends the function of a one-way valve. As the channels are arranged from a flexible material, such as rubber, the opening at the ends will collapse/close due to the pressure inside the chamber if no pressure is applied from the outside and into the channel.

[0046] According to a further embodiment of the first aspect of the invention, the barrier main part and/or the injection tube having an outer layer of fire-resistant material, such as a woven polyester and an inner fluid tight liner, such as a rubber liner.

[0047] In order to render the barrier resistant to fire and still fluid tight, the barrier main part and/or the injection tube comprises an outer layer of a fire-resistant material, such as a woven polyester, glass fiber, ceramic textile, or any other textile with high temperature resistance, all these above-mentioned materials can have water tight coating on the inside, or an inner fluid tight liner, such as, but not limited to a rubber liner.

[0048] According to a second aspect of the present invention, the above objects and advantages are obtained by:

A system for extinguishing a fire in a vehicle, such as an electric car, the system comprising:

- a storage medium, such as a tank, being external the vehicle, and containing brine as a fire extinguishing medium, and
- a delivery system for delivering the fire extinguishing medium from the storage medium to the inside of the vehicle.

[0049] The fire extinguishing system is preferably arranged proximate locations having a number of parked vehicles, such as ferries, parking garages, underground parking's, parking lots, tunnels etc.

[0050] The fire extinguishing system comprises a storage medium which contains the fire extinguishing medium being a brine which is to be injected into the vehicle.

[0051] The fire extinguishing medium is preferably cold, such as having a temperature below 0 degrees Celsius, and the storage medium is preferably insulated and comprises internal means for circulating the fire extinguishing medium within the storage medium.

[0052] The system may be arranged with a cooling system for cooling the brine, as cooled brine as the most optimal effect on a burning or overheated battery.

[0053] However, as the salt concentration of brine is very high, even brine at temperatures above 0 degrees Celsius provides excellent cooling effect on the battery, as the salt absorbs heat effectively. Therefore the cooling system may in some cases be avoided.

[0054] The storage medium may comprise internal circulation means, such as a circulation pump, for circulating the cold fire extinguishing medium within the storage medium in order to ensure a uniform cold temperature.

[0055] The storage medium and the cooling system are arranged such that the fire extinguishing medium can be circulated between the storage medium and the cooling system for cooling the fire extinguishing medium to a predefined cold temperature. The fire extinguishing system preferably comprises a circulation pump for circulating the fire extinguishing medium between the storage medium and a heat exchanger of the cooling system, such as an evaporator.

[0056] The fire extinguishing system further comprises a delivery system for delivering the fire extinguishing medium from the storage medium and into the vehicle.

[0057] The delivery system comprises in a preferred embodiment a flexible hose, similar to a firefighting hose, which may be directly or indirectly connected to the storage medium. In order for the storage medium to deliver the stored fire extinguishing medium into e.g., an burning EV, the storage medium preferably comprises a pump which may be integrated with the storage medium. In another embodiment, an external pump may be connected to the storage medium for pumping out the fire extinguishing medium.

[0058] The fire extinguishing medium is preferable a brine, which is a high concentration of salt (typically sodium chloride) in a liquid such as water. Brine may be a salt solution ranging from 3.5% up to approximate 26% which will typically be a completely saturated solution and is typically used in the cooking industry, where it is used to preserve or season foods.

[0059] Brine is also used as a secondary fluid in large refrigeration systems for the transport of thermal energy and may also be used for de-icing, e.g., the deicing of roads.

[0060] An advantage of using brine as a fire extinguishing medium, is that the medium is capable of carrying a very large amount of cooling energy into the interior of the vehicle, and therefore into contact with the burning or overheated EV battery. E.g., when brine is applied at a 23.3% concentration (76.7% water), it will freeze (without any additional dilution) at approx. -21 degrees Celsius, and therefore the salt brine is a liquid sub-stant, and easy pumpable down to below -21 celsius. Arranging the brine with, chemical additional antifreeze liquid, such as methanol, ethanol or any other antifreeze lowers the freezing temperature to as low as approximate -50 degrees Celsius.

[0061] In order to increase the maximum lower temperature of the fire extinguishing medium, it may comprise anti-freeze agents, such as ethylene or propylene glycerol or any other antifreeze. Using such agents may lower the freezing temperature of the brine, even below -50 degrees Celsius.

[0062] In the most preferred embodiment, the fire extinguishing medium, such as a brine, has a temperature of between -20 and -30 degrees. Arranging the medium with such temperature, provides the most optimal cooling temperature, compared the energy used for the cooling system to cool down the medium. Depending on the size of the burning and/or overheated battery, a temperature of between -20 and -30 is sufficient to extinguish/cool down a standard sized EV battery.

[0063] If the fire extinguishing system is to be used for larger EV vehicles, such as EV trucks or busses having larger sized batteries, a lower temperature of the medium may be needed.

[0064] When pumping the fire extinguishing medium into a vehicle, the increased viscosity minimizes the flowing out of the fire extinguishing medium through small openings of the car/decreases the rate of flowing out. Hereby, the fire extinguishing medium is concealed within the vehicle for a longer period of time.

[0065] Arranging the brine with a concentration of 20% (80% water) provides the possibility, without the use of additives, such as anti-freeze agents, to cool the brine to a temperature of below -20 degrees Celsius.

[0066] The cooling system provides the possibility of continuously circulating the fire extinguishing system between the storage medium, such as a tank, and a heat exchanger, such as an evaporator in the cooling system. The system may comprise a control system having sensors, such as temperature sensors for continuously monitoring the temperature of the fire extinguishing medium, such that the medium always has a desired temperature.

[0067] The fire extinguishing system is preferably arranged as a modular system, such that the storage medium may be disconnected and transported to another location of need, for extinguishing a fire in a remote located EV. The fire extinguishing system is therefore preferably arranged with a conduit system between the storage medium and the cooling system, where the conduit system comprises a releasable coupling system for disconnecting the storage medium from the cooling system. Preferably, the conduit system comprises a bypass for continuously circulating the fire extinguishing medium through the heat exchanger.

[0068] Hereby, the storage medium can easily be disconnected from the cooling system and transported, e.g., on a truck, to a remote location. Further, the storage medium and the conduit system is preferably heat insulated such that the temperature of the fire extinguishing medium is best preserved.

[0069] The fire extinguishing system is preferably arranged in relation to a parking environment such as a ferry, parking garages, underground parking, parking lots, tunnels etc. where these environments may have a relatively large parking area comprising a high number of parked vehicles.

[0070] In such situations, it is necessary for the fire extinguishing system to be able to cover the entire area and thereby being able to extinguish a fire in a most remotely located vehicle. In relation to ferries, underground parking facilities, and multilevel parking garages, it as desirable for the fire extinguishing system to cover all levels.

[0071] It is preferred that the fire extinguishing system comprises a delivery system having a first part which is

stationary arranged in relation to the storage medium and the cooling system. The stationary first part preferably comprises a number of insulated pipes/conduits fixedly installed in the environment, such as a ferry, garage etc. The first stationary part may be a grid of pipes which extends from the storage medium over a main part of the parking area, and if the parking area covers multiple levels, the grid preferably extends over the individual levels.

[0072] The fire extinguishing system further comprises a second flexible part, arranged non-stationary in relation to the storage medium and the cooling system, and arranged for delivering the fire extinguishing medium from the storage medium, and into the vehicle for extinguishing/cooling down the EV battery. The second flexible part is preferable arranged as a hose, which is typically a fire-fighting hose, and coupled to the stationary part, via a valve, such as a hose valve, in a disconnectable manner.

[0073] The stationary first part preferable comprises several of such valves, located along the insulated pipes/conduits or over the grid, at specific locations. Hereby, when a fire or an overheated battery in a vehicle is detected, the second flexible part is coupled to the nearest valve, such that the second flexible part may reach the vehicle, e.g., down through a row of parked cars, for pumping in the fire extinguishing medium.

[0074] Alternatively, the second flexible part may be coupled directly to the storage medium for delivering the fire extinguishing medium without using the first stationary part. It is hereby achieved that the system can deliver fire extinguishing medium outside the area of the first stationary part. This embodiment is particularly useful in the situation as de-scribed earlier, where the storage medium is disconnected from the cooling system and transported elsewhere e.g., on a truck, for use at a remote location.

[0075] The aim of the fire extinguishing system is to extinguish or prevent fires in substantial specific vehicle sizes. The object of the system is to inject fire extinguishing material primary into passenger vehicles such as cars, where the internal volume of such cars does not vary a great deal compared to e.g. the internal volume of a bus. A typical volume of a family car of course varies, dependent on the model, but is typically approx. 3 -5 m3.

[0076] When installing the system, it is known what type of vehicle is the target of the fire extinguishing system and the volume of the storage medium is therefore preferably within 3-5 m3, and preferably above such that the system can continue pumping fire extinguishing medium into the vehicle, after the vehicle has been substantially filled. In a further embodiment, the storage medium may comprise an adjustable interior volume, such that the amount of fire extinguishing material within the storage medium can be regulated according to the need. For that purpose, the storage medium comprises an interior wall element which may be displaced within the storage medium, hereby decreasing, or increasing the interior volume, in which the fire extinguishing medium is stored.

[0077] The system preferably comprises a salt regulating mechanism, such as a salt regulating mechanism arranged in connection with the cooling system. The system may comprise sensors for detecting the salt concentration of the fire extinguishing medium, and if the salt concentration falls outside a certain predefined range, such as a minimal lower value, the salt regulating mechanism adds an amount of salt, such that the concentration falls within the predefined range.

[0078] If the temperature of the fire extinguishing medium is to be lowered compared to a present situation, the salt concentration may not be high enough, whereby there is a risk that the fire extinguishing medium freezes. To prevent the temperature of the fire extinguishing medium falling below a specific freezing point when a lower temperature is needed, the salt concentration regulation mechanism adds salt to the fire extinguishing medium and hereby increasing the concentration.

[0079] According to a further embodiment of the second aspect of the invention, the system further comprises a barrier according to any of the embodiments according to the first aspect of the invention.

[0080] By arranging the system with a barrier as defined earlier, it is possible to provide a fire extinguishing material to a burning or overheated EV battery and/or burning vehicle in an effective manner and which limits the amount of needed fire extinguishing medium. The above-defined system provides the possibility of arranging maximum fire extinguishing properties and maximum removal of heat from an EV battery in combination with a barrier which results in minimum use of fire extinguishing medium and insurance of the EV-battery during cooling being submerged into the medium and further combined with the element of fast and effective deployment of the barrier, which all together results in a system capable in a simple, fast and effective manner of preventing a burning or overheated EV battery from causing a disaster.

[0081] According to a further embodiment of the second aspect of the invention, the brine having a sub-zero temperature.

[0082] Brine cooled to a sub-zero temperature as the maximum cooling effect of the EV battery. The temperature of the brine is below 0 degrees such below -10 degrees Celsius, preferably below -20 degrees, such as between -20 and -50 degrees, most preferred between -20 and -30 degrees. In the most preferred embodiment, the fire extinguishing medium, such as a brine, has a temperature of between -20 and -30 degrees. Arranging the medium with such temperature, provides the most optimal cooling temperature, compared with the energy used for the cooling system to cool down the medium. Depending on the size of the burning and/or overheated battery, a temperature of between -20 and -30 is sufficient to extinguish/cool down a standard-sized EV battery.

[0083] If the fire extinguishing system is to be used for larger EV vehicles, such as EV trucks or busses having larger sized batteries, a lower temperature of the medium may be needed.

[0084] According to a further embodiment of the second aspect of the invention, the brine having a temperature above zero degrees.

[0085] As the salt concentration of brine is very high, even brine at temperatures above 0 degrees Celsius provides excellent cooling effect on the battery, as the salt absorbs heat effectively. Therefore, the cooling system may in some cases be avoided.

[0086] According to a third aspect of the present invention, the above objects and advantages are obtained by: A method for extinguishing a fire in a vehicle, such as an EV, the method comprising the following steps:

- providing a barrier according to any of the embodiments of the first aspect of the invention around the vehicle,
- erecting the barrier from the first state to the second state,
- injecting a fire extinguishing medium, such as brine into the vehicle, and
- encapsulating the medium within the perimeter of the barrier.

[0087] With the above-defined method, there is provided a method for extinguishing and/or cooling down a battery in an EV, where a cooling medium is injected into the vehicle, and a burning car battery or an overheated battery can be extinguished and/or cooled down in an easy and safe manner, such that the car no longer poses a risk or the vehicle can be removed from the parking area without causing further damage to the surroundings.

[0088] According to a further embodiment of the third aspect of the invention, the fire extinguishing medium being brine having a temperature of below -10 degrees, preferably a temperature below -20 degrees, such as between -20 and -50 degrees, most preferred between -20 and -30 degrees, such that at least part of the material of the barrier which is in contact with the ground surface, freezes to the ground surface hereby connecting the barrier to the ground surface.

[0089] The temperature of the brine is below -10 degrees Celsius, preferably a temperature below -20 degrees, such as between -20 and -50 degrees, most preferred between - 20 and -30 degrees. In the most preferred embodiment, the fire extinguishing medium, such as a brine, has a temperature of between -20 and -30 degrees. Arranging the medium with such temperature, provides the most optimal cooling temperature, compared with the energy used for the cooling system to cool down the medium. Depending on the size of the burning and/or overheated battery, a temperature of between -20 and -30 is sufficient to extinguish/cool down a standard-sized EV battery.

[0090] If the fire extinguishing system is to be used for larger EV vehicles, such as EV trucks or busses having larger sized batteries, a lower temperature of the medium may be needed.

[0091] The extremely cold brine which is injected into the car, still has a very low temperature when flowing out of the car and into the opening of the barrier, which very low temperature cools down the junction between the barrier and the ground such as a car deck of a shop. Hereby the barrier freezes to the ground and further prevents the brine from leaking out underneath the barrier.

[0092] In an alternative embodiment, the brine is not injected into the car, but filled into the opening of the barrier hereby flooding the EV-battery.

Fig. 1A-1B is a perspective view of a ship having a parking area with a burning car.

Fig. 2A is a plane view of a cross-section through the ship in figure 1A.

Fig. 2B is an enlarged view of a part of fig. 2A.

Fig. 3A, 3C are perspective views of a burning car with a barrier being deployed.

Fig, 3B and 3D are cross-sectional views of the barrier in fig. 3A and 3C.

Fig. 3E is a side view of an undeployed barrier.

Fig. 4A and 4C are perspective views of a burning var with a deployed barrier.

Fig, 4B, 4D are cross-sectional views of the barrier in fig. 4A and 4C.

Figs. 5-6 is are perspective views of a barrier.

Fig. 7 shows a diagram of a fire extinguishing system.

[0093] The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which exemplary embodiments of the invention are shown. The invention may, however, be embodied in different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Like reference numerals refer to like elements throughout. Like elements will thus not be described in detail with respect to the description of each figure. The invention is in the following disclosed in relation to a parking area of a ship, but might as well be described in relation to the different types of parking areas, e.g., parking garages, underground parkings, parking lots, tunnels etc.

[0094] Fig. 1A-1B show perspective views of a ship having a parking area with a burning car 24. Figure 1A and 1B show the ship having a number of cars 24 arranged in two levels and where one of the cars 24 are on fire. It is apparent that the fire may easily spread to the nearby located other cars, or even spread to the construction of the ship.

[0095] Fig. 2A shows a plane view of a cross-section through the ship in figure 1A.

[0096] The drawing shows the ship comprising a parking area 46 having a number of cars 24. It should be understood that the illustrated level of the ship may comprise a larger parking area 46 than the one shown. Adjacent the parking area 46 at the bow of the ship is illustrated a fire extinguishing system 10. Though the fire ex-

tinguishing system 10 is illustrated at the bow of the ship, it may be located elsewhere on the show, e.g., at the stern or on a different level than the one shown.

[0097] Fig. 2B shows an enlarged view of a part of fig. 2A. The figure shows an enlarged view of part of the parking area 46 having a number of parked cars 24. The figure shows a fire extinguishing system 10, which in the shown embodiment comprises a storage medium 12, which in a preferred embodiment is a tank which stores the fire extinguishing medium, such as brine. The storage medium will in the following be described as a tank but should not be understood as limited to such definition.

[0098] The fire extinguishing system 10 is shown with a cooling system 14 for cooling the brine 22. Brine cooled to a sub-zero temperature has the maximum cooling effect on the EV battery, but due to the very high salt concentration of the brine, heat from the battery is effectively lead from the battery and to the brine. Therefore, the fire extinguishing system 10 may be arranged without the cooling system 14.

[0099] The tank 12, which preferable is an insulated tank 12, stores the cooled brine 22, and the system is arranged with conduits between the tank 12 and the cooling system 14, such that the brine 22 can circulate between the tank 12 and the cooling system. It is hereby ensured that the cooling system 14 continuously cools the brine 22, such that the brine 22 in the tank 12 is stored at a specific constantly low temperature. Any loss of energy from the brine through the tank 12 and the conduits is therefore compensated for.

[0100] The fire extinguishing system 10 comprises a delivery system which is arranged for delivering the brine 22 which is stored in the tank into the interior of the car 24 with the burning or overheated battery.

[0101] The delivery system is illustrated with a first stationary delivery system 16 which is connected to the tank 12, and which is preferably arranged as a series of pipes, preferably insulated pipes, which are connected to the construction of the ship, such as pipes installed to the walls or ceilings on the illustrated level of the ship.

[0102] The delivery system further comprises a second flexible delivery system 18 which is connected to the first stationary delivery system 16, and which is preferably arranged as a flexible hose, such as a hose similar to a firefighting hose.

[0103] The first stationary delivery system 16 is arranged substantially along the entire parking area 46 and is preferably arranged with a number of connection points 42 located on the first stationary delivery system 16 at specific intervals such that the second flexible delivery system 18 can be connected at any of these connection points, typically the connection point which is located closest to the car 24 in question. The connection points are preferably arranged as a hose valve, such as a hose valve which is typically in fire hydrants.

[0104] The second flexible delivery system is optimally arranged with injection means 20 (shown in fig. 3B), such as a nozzle for injecting the brine into the car 24. When there is a need to use the fire extinguishing system 10, in the event of a burning or overheated battery, a hole is made in the body or the car, such as a hole through the roof of the car, with a specific tool which arranges a hole with a specific diameter, and the injection means 20 are dimensioned to fit the hole. It should be understood that multiple holes may be made in the car, and at different locations than in the roof. Therefore, holes may be made in other parts of the car such as the bonnet or the rear of the car etc. E.g., the injection means 20 is a nozzle having a tapered shape, such that a first part of the nozzle penetrates the interior of the car to a certain point where the outer diameter of the taper corresponds to the diameter of the hole which acts as a stop. The injection means 20 and the second flexible delivery system 18 is hereby kept in a stabile position during the injection of brine into the car 24.

[0105] Fig. 3A shows a perspective view of a burning car 24. Batteries 58 are typically mounted in the vehicle at the lower most part, such as in the bottom of the vehicle. Therefore, it is needed to install a barrier 48 which surrounds the vehicle, and which has a height sufficient to encapsulate the fire extinguishing medium at a level which covers the batteries 58. As the batteries 58 are located close to the ground and the barrier 48 therefore requires a limited height, it is possible to roll up of fold the barrier 48 for storage and for easier deployment. A larger barrier 48, which for example has a height similar to the height of the vehicle, may not be rolled up of folded and deployed according to the barrier 48 of the present invention.

[0106] Figure 3A shown the barrier 48 being rolled up from two ends of the barrier 48 and toward the center of the barrier 48 and arranged on top of the burning car.

[0107] The barrier comprises a barrier main part 48' (see fig. 5) which comprises a barrier chamber 50 and a channel 52 (see fig. 3D) having a smaller volume than the barrier chamber 50. The channel 52 is arranged as a tube preferably internally in the barrier chamber 50 but may be arranged on the exterior of the barrier chamber 50.

[0108] The barrier 48 is shown with an injection tube 56 which is in fluid connection with a channel 52 (se fig. 3D), such that when the channel 52 is inflated or filled with a fluid, the channel unrolls/unfolds and forces the barrier chamber 50 to unroll/unfold.

[0109] The channel 52 may be in fluid connection with the barrier chamber 50, such that when the channel 52 is filled with water, the barrier 48 unfolds and water continues to be pumped through the channel 52 and into the barrier chamber 50.

[0110] In the embodiment where the channel 52 is inflated with an air/gastype, it is preferred that the channel 52 is arranged as a closed compartment which is not in fluid connection with the barrier chamber 50. In this embodiment, the barrier chamber 50 is connected to a water source which fills the barrier chamber 50 after, or simultaneous with the channel 52 being inflated.

[0111] In order for the barrier 48 to prevent the fire extinguishing medium from leaking out from under the barrier 48, the barrier 48 needs a certain mass and is therefore preferably filled with a fluid such as water.

[0112] The injection tube 56 may be connected to a source of fluid, such as a water source or by air/gas source, such as Co2 or any other airtype/gastype which may inflate the channel. Such water source may be a pump, which pumps in sea water, when the barrier 48 is used in a ship, or any other source of water which may quickly inject water into the barrier 48 at sufficient pressure such as up to 6 bar or more.

[0113] The barrier 48, which is relatively light due to the limited height, can be easily and quickly arranged on top of the car 24, e.g. by two persons for deployment.

[0114] As the barrier 48 is arranged from a fire-resistant material, such as a fire-resistant fabric, glass fiber, ceramic textile, or any other textile with high temperature and fire-resistant material and the following deployment operation is executed within a few seconds, the barrier 48 will not be destroyed when placed on top of the burning car 24.

[0115] Instead of an integrated injection tube 56, the barrier 48 may be arranged with coupling means (not shown) in the main part 48', such that an external hose, e.g., a standard firefighting hose may be connected to the main part 48' for injecting water into the channel 52.

[0116] Fig. 3B shows a completely collapsed barrier 48 in the situation illustrated in figure 3A. As can be seen, the barrier 48 is substantially flat, and can therefore be rolled-up or folded.

[0117] Fic 3C shows the barrier 48 being deployed. A fluid, such as water, is injected from a water source (not shown) under pressure into the injection tube 56 and into a channel 52 at one side of the barrier 48. The injection tube 56 branches off before the channel 52 into a second injection tube 56', which second injection tube 56' communicates with a channel 52 (see figs. 5 and 6) in the opposite side of the barrier 48.

[0118] As fluid is injected into the channels 52 on opposite sides of the barrier 48, the barrier 48 quickly unrolls on top of the car.

[0119] Fig. 3E shows a side view of a rolled-up barrier 48.

[0120] Fig.4A shows a perspective view of a burning car 24. In order to be able to extinguish the flames 26 within the interior of the car 24 and prevent a spreading of the fire, a hole is being made in the roof construction such that the brine 22 may be injected into the interior of the car 24. The hole is being made by penetration means 28 which may be a penetration/piercing nozzle or other type of penetration means which is manually or automatically operated.

[0121] In order, for the car 24 to carry maximum mass of brine 22, it is preferred to arrange the hole in the roof construction of the car. Alternatively, the brine 22 may be injected into the car 24 through a broken window. As the car will always have smaller openings, e.g. through the ventilation system or through the bottom of the car, the brine 22 will escape from the car and the escaped brine will be kept by the barrier 48 within the perimeter of the car 24.

[0122] As shown in the figure, the barrier 48 has been completely unrolled, and as it unrolls it automatically "drops" down and around the car 24 while the barrier chamber 50 is being filled with water.

[0123] Fig. 4B shows the barrier 48 in figure 4A, in which the barrier chamber 50 is partly filled with water.

[0124] Fig. 4C shows a perspective view of a burning car 24, where the barrier 48 has been deployed and filled with water such that the height of the barrier 48, reaches the height of the batteries 58 installed in the bottom of the car 24 (see fog. 3A) and the car 24 has been filled with brine 22.

[0125] The flexible delivery system 18, such as a hose, with the injection means 20 is arranged connected with the hole in the roof of the car 24, and the brine 22 is injected through the hole and into the car 24. After the car 24 has been substantially filled with brine 22, an amount of brine 22 will leak out of the interior through openings or broken windows etc. and the fire extinguishing system 10 will continue to inject brine into the car 24.

[0126] The leaked-out brine 22 is encapsulated within the perimeter of the car 24 and will eventually reach a height where the batteries 58 of the car 24 are submerged in the brine, such that the heat from the batteries 58 will be cooled down via the brine lead away from the batteries 58.

[0127] Fig. 4D shows the barrier in fig. 4C where the barrier chamber 50 is completely filled with water.

[0128] Figs. 5-6 are perspective view of a barrier.

[0129] The barrier 48 shown in fig. 5 comprises injection tubes 56, 56' connected to channels at opposite sides of the barrier 48. Each injection tube 56, 56', communicates with a channel 52 at a side of the barrier 48 respectively. The channels 52 are arranged extending along the longitudinal sides of the barrier 48 and each channel terminates towards the ends of the barrier 48. Each channel 52, which may be arranged e.g. as a hose, is connected along the length thereof completely or partly to the barrier chamber 50. In the shown embodiment, the ends of the channels 52 are arranged "loose" within the barrier chamber 50, which gives the channel ends the function of a one-way valve, to ensure that water may flow through the channels 52 and into the barrier chamber 50, but in the event that the injection tubes 56, 56' get damaged e.g. from the fire, the water will not flow from the barrier chamber 50 and out through the injection tubes 56, 56'. In an alternative embodiment, the barrier 48 comprises mechanical one-way valves arranged in or close to the junction, between the injection tubes 56, 56' and the channels 52.

[0130] Fig. 6 shows an alternative embodiment where the channels 52 extend along the longitudinal direction of the barrier and along a substantial part of the latitudinal ends of the barrier 48.

[0131] The barrier is arranged such that the channels 52 extend in the longitudinal direction of the barrier 48 and continues in the latitudinal direction of the barrier 48 at both ends thereof.

[0132] Each channel terminates toward the center of the latitudinal sides of the barrier and the injected fluid from the outside flows through the channels and into the barrier chamber 50 at the latitudinal sides of the barrier 48. Arranging the channels 52 in both the longitudinal and latitudinal direction of the barrier 48, ensures that the shape of the barrier 48 can be maintained in both directions, when then the barrier 48 being unrolled/unfolded and ensures that the barrier gets its full final shape.

[0133] Fig. 7 shows a diagram of a fire extinguishing system 10.

[0134] The fire extinguishing system comprises a tank 12 for storing the brine 22 and a flexible delivery system 18 for delivering the brine 22 from the tank 12 and into the car 24. The fire extinguishing system 10 also comprises a pump (not shown) for pumping the brine from the tank 12 and through the delivery system 18.

[0135] The fire extinguishing system 10 is shown connected to a cooling system 14 for cooling the brine. As described earlier, cooled brine, such as brine below 0 degrees Celsius, preferably brine 22 below minus 20 degrees Celsius provides optimum effect when cooling a burning or overheated car battery. However, due to the very high concentration of salt in the brine, heat is lead out of and away from the batteries. Therefore, in situations where it is not possible to arranged a cooling system, e.g., due to limited available space, the fire extinguishing system 10 will be arranged without the cooling system.

[0136] The illustrated cooling system 14 is one possible embodiment but it should be understood that the cooling system 14 may be arranged differently.

[0137] The system comprises a closed circuit having a refrigerant such as NH3 (ammonia) or other type of refrigerant such as Co2, freon etc. The closed circuit comprises a compressor 30 which compresses the ammonia which hereby increases the temperature of the ammonia. The heated vapor ammonia enters a cold condenser 32 which absorbs the heat from the ammonia which is converted into liquid. The condenser 32 is preferably connected to a cooling tower (not shown) which water cools the condenser. The liquid ammonia enters a receiver where it accumulates, in order to deliver a continues amount of ammonia to the following components. After the receiver, the high-pressure liquid ammonia enters an expansion valve 36 where it expands and the pressure de-creases whereby the temperature falls and the ammonia is a very cold liquid. The liquid and very cold ammonia then enter the evaporator 38 where the refrigerant effect occurs. The evaporator 38 is connected to the tank 12 by conduits, such that the brine 22, which is stored inside the tank 12 can be pumped, by a pump 40, through the evaporator 38 where the brine is cooled down to the desired temperature. Preferably, the pump 40 continuously pumps the brine through the evaporator 38 to keep a constant cold temperature of the brine inside the tank 12.

[0138] From the tank 12, the brine 22 is delivered to the car 24 (not shown) through the delivery system, which in the shown embodiment is illustrated by the flexible delivery system 18. The delivery system may consist only of the flexible delivery system 18, or both stationary delivery system 16 and the flexible delivery system 18.

[0139] The conduits between the tank 12 and the evaporator is in a preferred embodiment, as shown, arranged with a bypass string having a bypass valve 44, and the circuits to and from the tank each comprise second bypass valves, such that the flow of brine through the evaporator 38 can circumvent the tank 12. It is hereby achieved that the tank 12 can be disconnected from the cooling system and transported elsewhere.

[0140] The fire extinguishing system further comprises pumping means (not shown), similar to the pump 40, for pumping the brine 22 from the tank and into the car 24.

[0141] In the following is given a list of reference signs that are used in the detailed description of the invention and the drawings referred to in the detailed description of the invention.

10	Fire extinguishing system
12	Storage medium
14	Cooling system
16	Stationary delivery system
18	Flexible delivery system
20	Injection means
22	Fire extinguishing medium
24	Car
26	Flames
28	Penetration means
30	Compressor
32	Condenser
34	Receiver
36	Expansion valve
38	Evaporator
40	Pump
42	Connection point
44	Bypass valve
46	Parking area
48	Barrier
48'	Barrier main part
50	Barrier chamber
52	Channel
54	Channel outlet
56, 56'	Injection tube
58	Battery

Claims

1. A barrier for encapsulating a liquid medium, such as a fire extinguishing medium within the perimeter of a vehicle, such as a burning vehicle or an electric

vehicle with an overheated battery,

- said barrier comprising a main part having a circumferential chamber defining an opening for surrounding said vehicle,
- said circumferential chamber having a first volume, and
- said barrier comprising an integrated channel having a second volume being smaller than said first volume,
- said volume of said channel being in fluid connection with an outside of said barrier, such that a fluid, such as water, may be injected into said channel,
- said barrier being configured to be arranged in a collapsed state, such as a rolled-up or folded state, in a direction substantially perpendicular to said channels, such that when injecting a fluid into said channels, said barrier unrolls or unfolds in the direction of said channels into a second state where said circumferential chamber may surround said car.

2. A barrier according to claim 1, wherein said barrier comprising an elongated shape.

3. A barrier according to claims 1 or 2, wherein said barrier in said first state being rolled up or folded from opposite ends respectively and towards a center of said barrier.

4. A barrier according to any of claims 1-3, wherein said channel comprising an inlet at a position on said barrier where said opening has a diameter smaller than the largest diameter of said opening.

5. A barrier according to any of claims 2-4, wherein said barrier comprises two channels extending in a longitudinal direction of said barrier on opposite sides of said barrier.

6. A barrier according to claim 5, wherein said channels extending in said first longitudinal direction and in a second latitudinal direction of said barrier.

7. A barrier according to any of the previous claims, wherein said barrier comprises an injection tube, one end of said injection tube being connected to said channel, and the other end of said injection tube communicating with an outside of said barrier.

8. A barrier according to any of the previous claims, said channel and/or said injection tube comprising a valve, such as a one-way valve.

9. A barrier according to any of the previous claims, wherein said barrier main part and/or said injection tube having an outer layer of fire-resistant material, such as a woven polyester and an inner fluid tight liner, such as a rubber liner.

10. A system for extinguishing a fire in a vehicle, such as an electric car, said system comprising:

- a storage medium, such as a tank, being external said vehicle, and containing brine as a fire extinguishing medium, and
- a delivery system for delivering said fire extinguishing medium from said storage medium to the inside of said vehicle.

11. A system according to claim 10, comprising a barrier according to any of claims 1-9.

12. A system according to claim 11, said brine having a sub-zero temperature.

13. A system for extinguishing a fire in a vehicle according to claim 11, said brine having a temperature above zero degrees.

14. A method for extinguishing a fire in a vehicle, such as an EV, said method comprising the following steps:

- Providing a barrier according to any of claims 1-9 around said vehicle,
- Erecting said barrier from said first state to said second state,
- Injecting a fire extinguishing medium, such as brine into said vehicle, and
- Encapsulating said medium within the perimeter of said barrier.

15. A method according to claim 14, wherein said fire extinguishing medium being brine having a temperature of below 0 degrees, preferably a temperature below -20 degrees, such as between -20 and -50 degrees, most preferred between -20 and -30 degrees, such that at least part of the material of said barrier which is in contact with the ground surface freezes to said ground surface hereby connecting said barrier to said ground surface.

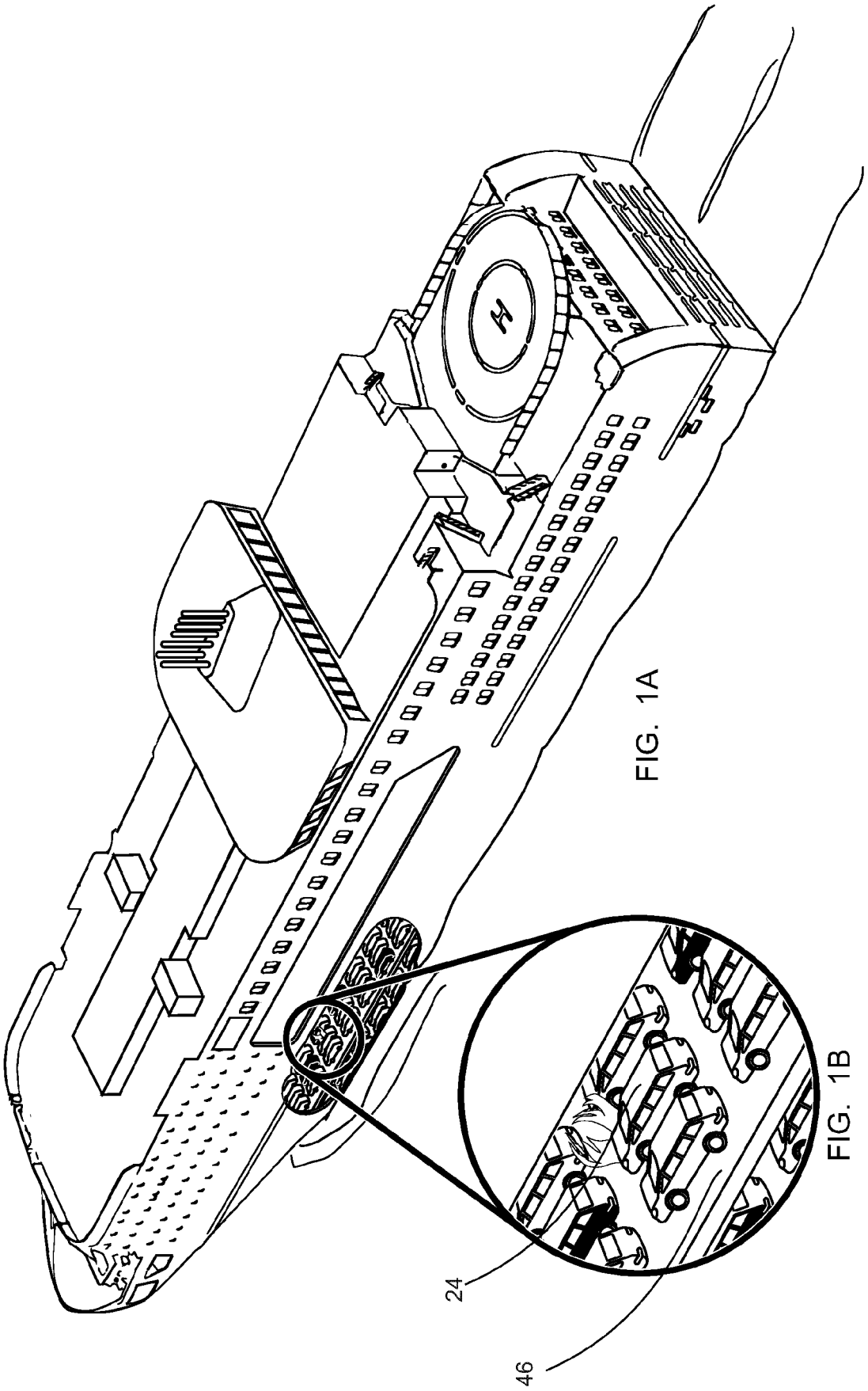

FIG. 1A

FIG. 1B

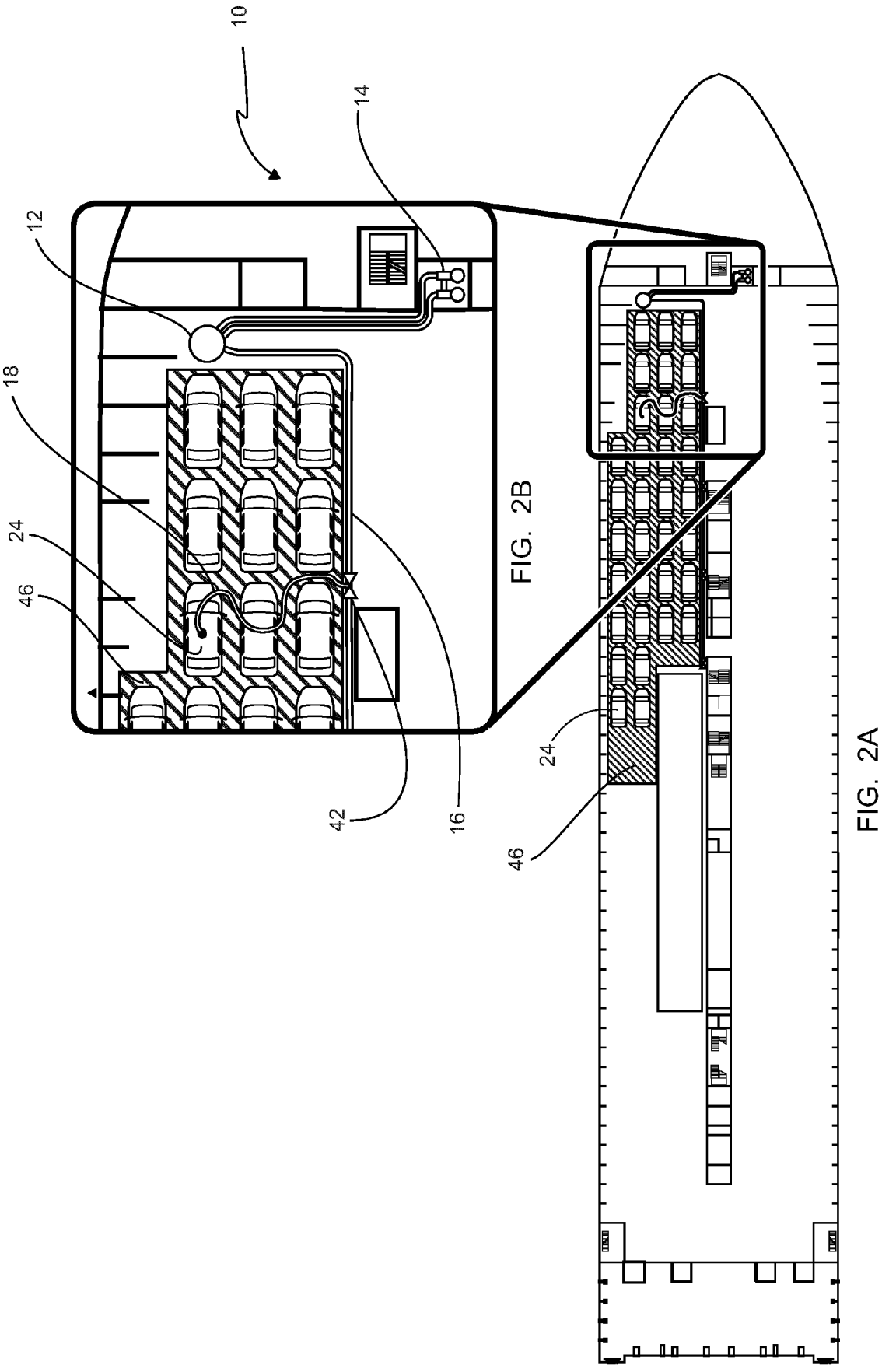

FIG. 2B

FIG. 2A

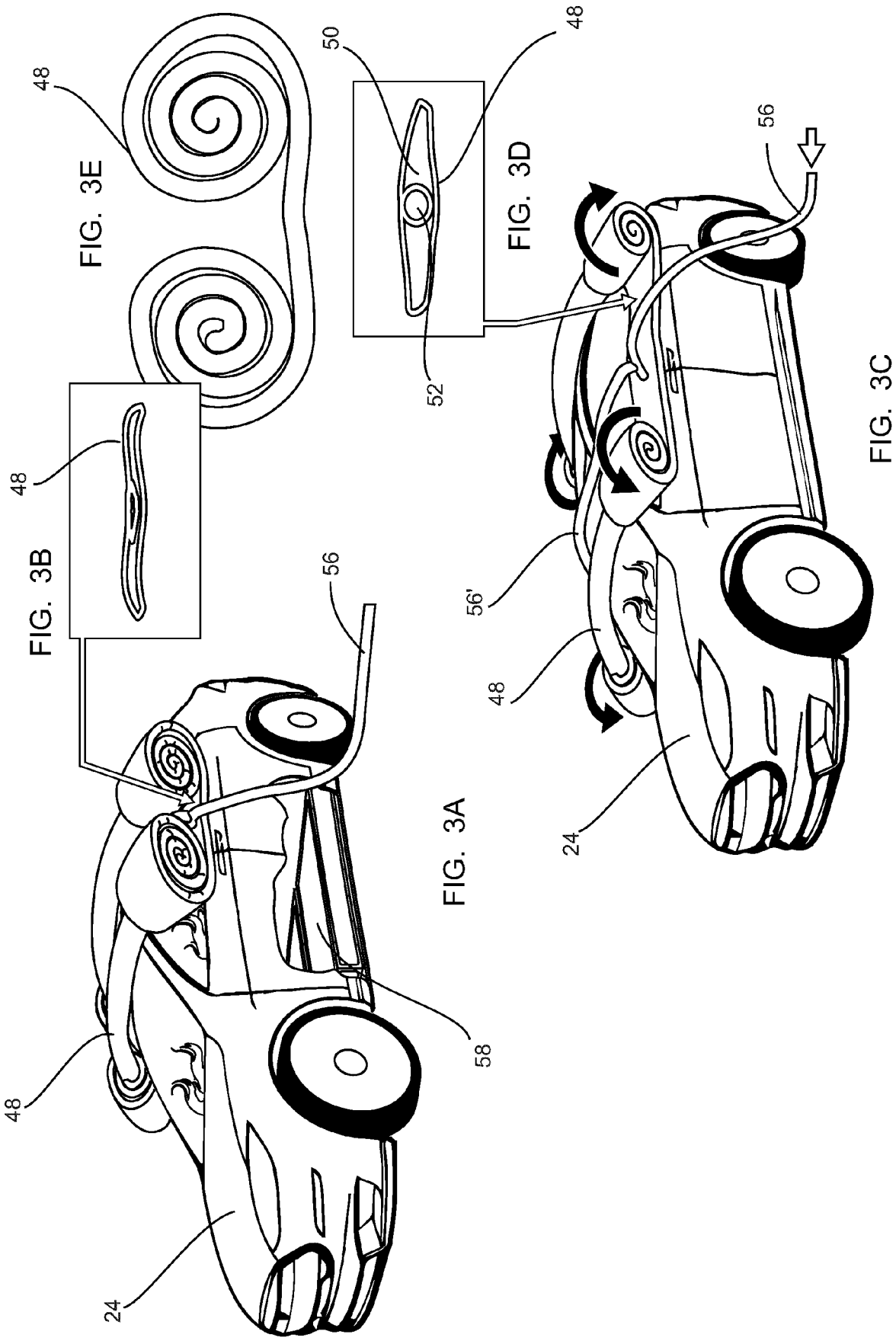
48
FIG. 3E
48
FIG. 3B
56
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FIG. 3A
50
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52
FIG. 3D
56
56'
48
24
FIG. 3C

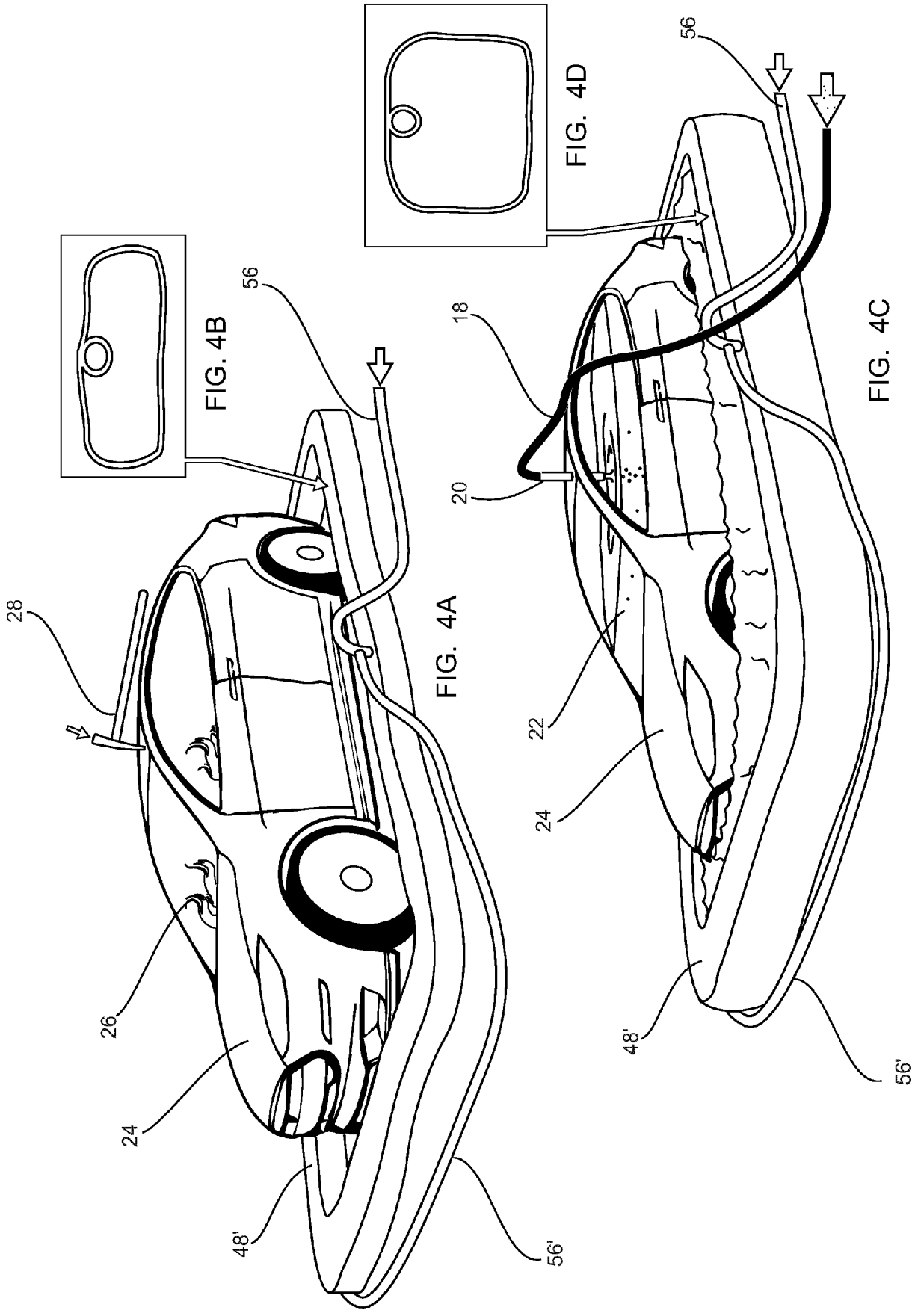
28
26
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FIG. 4A
FIG. 4B
18
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FIG. 4C
FIG. 4D

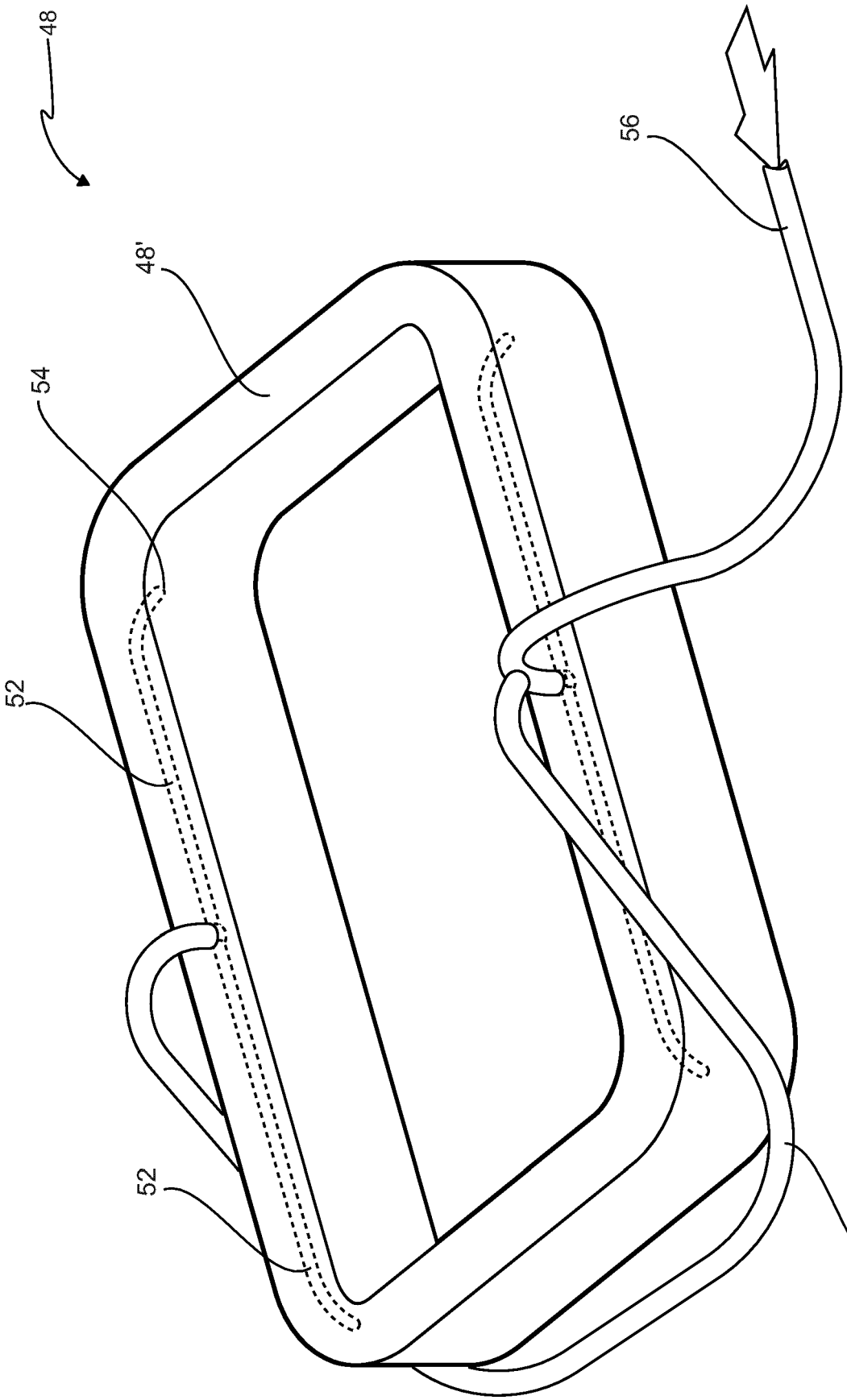

FIG. 5

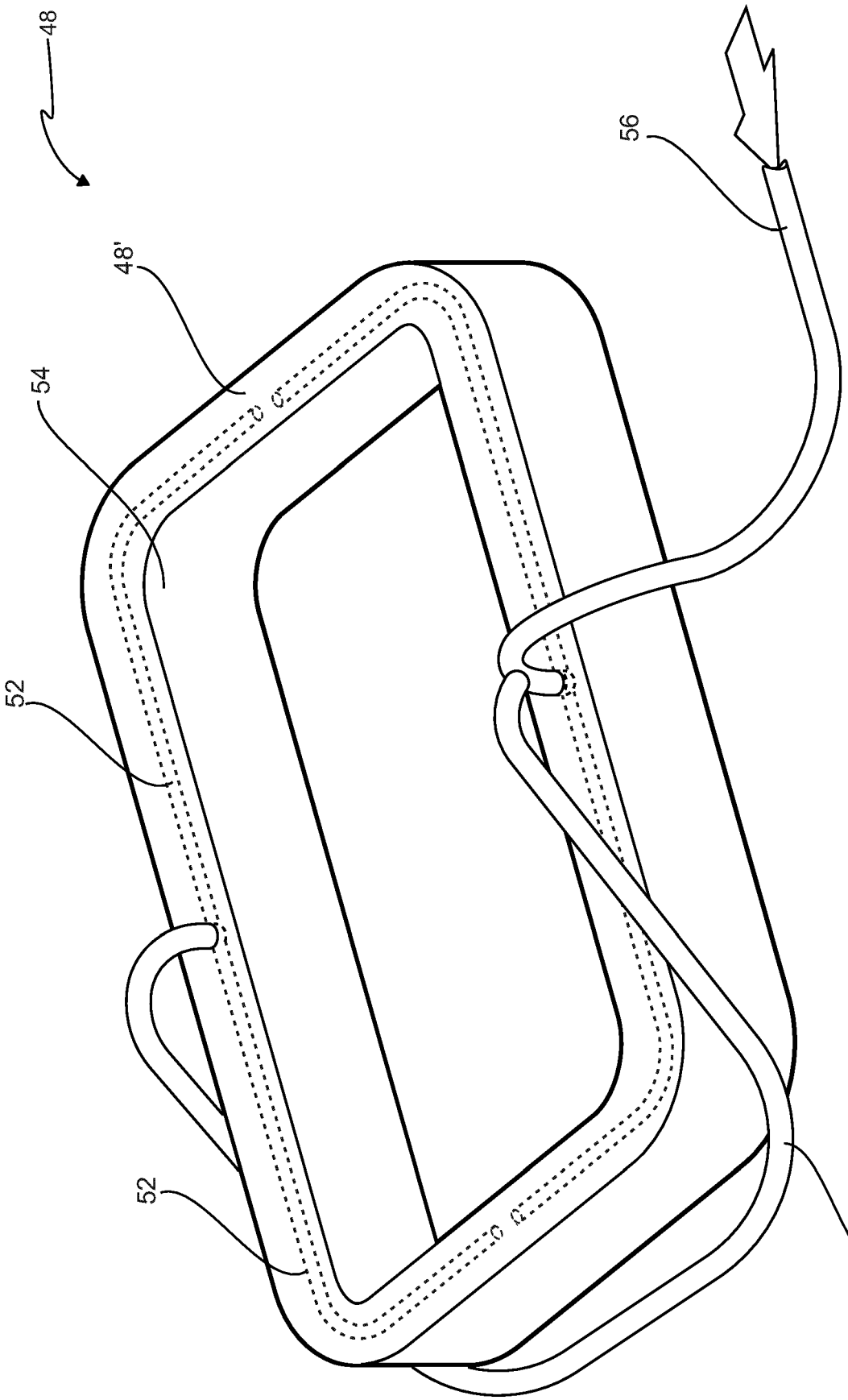

FIG. 6

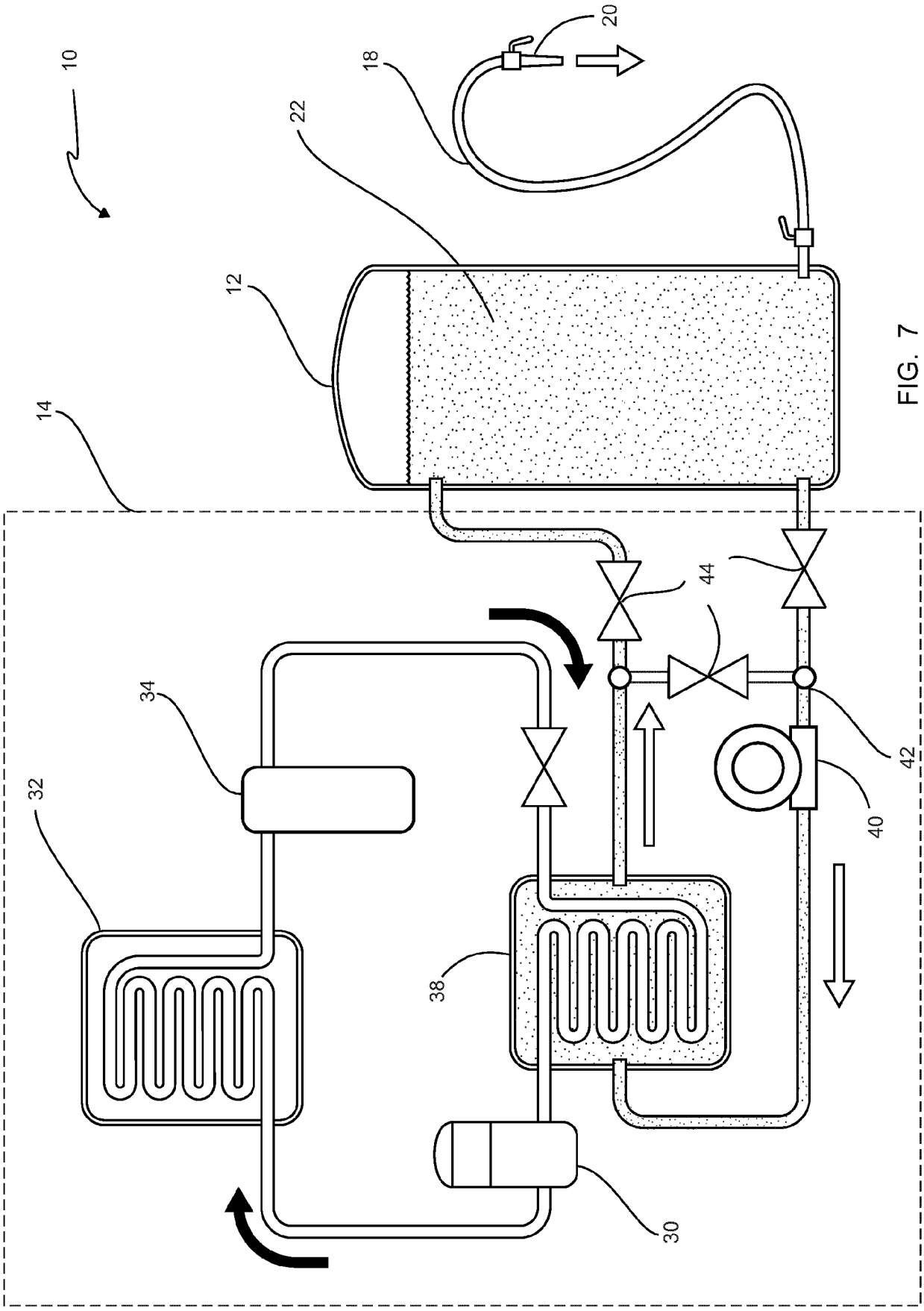

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 21 21 5003

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	WO 2021/219926 A1 (FIRESEA EQUIPMENT OY [FI]) 4 November 2021 (2021-11-04) * figures * * figures 1, 2 *	1-9	INV. A62C3/07 A62C3/16

TECHNICAL FIELDS SEARCHED (IPC)

A62C

~~The present search report has been drawn up for all claims~~

Place of search	Date of completion of the search	Examiner
The Hague	9 May 2022	Andlauer, Dominique

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons
.....
& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

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Application Number
EP 21 21 5003

CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing claims for which payment was due.

☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due and for those claims for which claims fees have been paid, namely claim(s):

☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for those claims for which no payment was due.

LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

☐ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.

☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.

☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:

☒ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:

1-9

☐ The present supplementary European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims (Rule 164 (1) EPC).

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LACK OF UNITY OF INVENTION
SHEET B

Application Number
EP 21 21 5003

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. claims: 1-9

Group 1: a barrier

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2. claims: 10-15

Group 2: a system for extinguishing fire in a vehicle with brine;
Group 3: a method for extinguishing fire in a vehicle with brine.

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 21 21 5003

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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09-05-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2021219926 A1	04-11-2021	FI 20205418 A1	15-04-2021
		WO 2021219926 A1	04-11-2021

EPO FORM P0459

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