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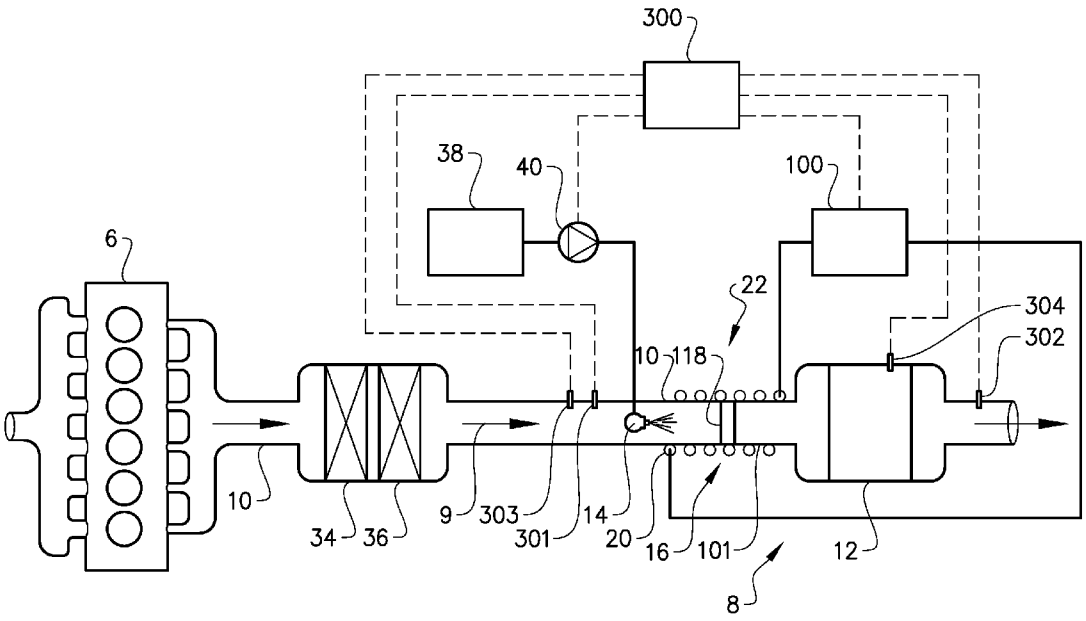

FIG. 2

(57) Abstract: The invention provides a method for controlling an exhaust gas treatment system (8) arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit (10), and a selective catalytic reduction catalyst (12) provided in the exhaust conduit (10), characterized by providing (S4, S102, S203) an alternating current through an electric conduit (20) located externally of the exhaust conduit (10), thereby providing induction heating of a portion (101, 118, 218, 318, 418, 18, 618, 718, 818, 918, 1018) of the exhaust conduit located upstream of the catalyst (12), and supplying (S5, S107), into the exhaust conduit (10) upstream of said portion (101, 118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) of the exhaust conduit, a reductant for an exhaust gas treatment process in the catalyst (12).

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A method for controlling an exhaust gas treatment system

TECHNICAL FIELD

The invention relates to a method for controlling an exhaust gas treatment system arranged to receive exhaust gases from an internal combustion engine, for example of a motor vehicle, the system comprising an exhaust conduit, and a selective catalytic reduction catalyst provided in the exhaust conduit. The invention also relates to a computer program, a computer readable medium and a control unit.

The invention can be applied in heavy-duty vehicles, such as trucks, buses and construction equipment, such as wheel loaders, haulers and excavators. Although the invention will be described with respect to a truck, the invention is not restricted to this particular vehicle, but may also be used in other vehicles such as buses, construction equipment and passenger cars. The invention may also be used on other transportation means such as ships and boats.

BACKGROUND

A nitrogen oxides (NOx) purification apparatus is used for reducing NOx contained in an exhaust gas discharged from an internal combustion engine. In particular, the NOx purification apparatus for an internal combustion engine uses a selective catalytic reduction (SCR) catalyst in the exhaust system of the diesel engine, in which a reducing agent such as urea is supplied to the exhaust gas for generating ammonia to be adsorbed on the SCR catalyst, thereby selectively reducing NOx contained in the exhaust gas.

However, the performance of the SCR is limited at low temperatures. In the case of ammonia being used as reductant where urea is used as precursor, ammonia will not be formed at temperatures below 160-180 degrees Celsius. This results in deposits, which can block the exhaust passage resulting in a decreased performance of the engine. Deposits can be formed on a wall even when the exhaust temperature is much higher when aqueous precursors hits the wall, by the combined effect of heat transfer to ambient and water evaporation keeping the wall temperature much lower.

Different types of catalysts have been investigated, which may work better at low temperatures. An alternative, or complement would be to increase the temperature in the exhaust gas treatment system. It is known to inject fuel after the engine, which is combusted in the exhaust gas treatment system, thereby increasing the temperature. This may however increase the fuel consumption, and it also increases the temperature on all parts of the exhaust gas treatment system.

It has also been suggested to use a separate heating equipment. WO2013127936A1 suggests an electric heater upstream of an SCR catalyst, for heating the exhaust gas flow, and feeding urea so that the urea impinges upon the electric heater. The heater includes a honeycomb structure in the exhaust conduit, through which an electric current is conducted. However, thereby sensitive electrical parts will be subjected to the aggressive environment in the exhaust conduit. For example, the urea will corrode such a heater. In addition, the wall of the exhaust conduit, downstream of the heater, will be cooler than the exhaust gases, and may therefore act as a deposit formation zone.

SUMMARY

An object of the invention is to improve an internal combustion engine exhaust gas treatment at low temperatures. An object of the invention is to improve an internal combustion engine exhaust gas treatment at low temperatures, while keeping the wear of an exhaust gas treatment system for the engine low.

The objects are achieved by a method according to claim 1. Thus, the object is reached with a method for controlling an exhaust gas treatment system arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit, and a selective catalytic reduction catalyst provided in the exhaust conduit, characterized by providing an alternating current through an electric conduit located externally of the exhaust conduit, thereby providing induction heating of a portion of the exhaust conduit located upstream of the catalyst, and supplying, into the exhaust conduit upstream of said portion of the exhaust conduit, a reductant for an exhaust gas treatment process in the catalyst.

The internal combustion engine may be a diesel engine. The exhaust conduit is herein also referred to as an exhaust passage. The exhaust conduit may be exemplified with a

tube, channel or other structure with one or more walls defining a space for an exhaust flow. It is understood that the selective catalytic reduction catalyst may provide nitrogen oxides (NOx) reduction. The supplied reductant may be e.g. urea. The reductant may be supplied by reductant supply means as exemplified below.

The electric conduit may be a coil surrounding the exhaust passage, i.e. an electric inductive coil. The electric conduit allows for an energy efficient design for providing power to the portion of the exhaust conduit. The coil may extend along a screw line surrounding the exhaust conduit. An electrical device may be adapted for supplying the alternating current to the electric conduit. Such a device may comprise a DC/AC converter, as exemplified below.

Thus, a heating arrangement may be provided, comprising the electric conduit positioned externally of the exhaust conduit. The alternating current may provide a fast, concentrated induction heating of the exhaust conduit portion. The alternating current may provide for localized heating of the specific surfaces, where deposits normally form. Thus, a targeted and energy efficient heating may be provided. Thereby, the exhaust gas treatment may be improved at low temperatures.

By providing the alternating current to the electric conduit, heating of the exhaust conduit portion and the exhaust gases may be achieved without any tubing and connections providing a communication between the exhaust conduit exterior and the exhaust conduit interior. This is advantageous in that the environment inside the exhaust conduit is aggressive and corrosive with a high temperature and varying load. Thereby, the exhaust gas treatment may be improved at low temperatures, while the wear of the exhaust gas treatment system is kept low. Also, there is no need to provide the exhaust conduit wall with holes for electric cables, as in said WO2013127936A1, with entailing problems of sealing such an arrangement. In addition, the invention makes it possible to avoid problems with isolating electrically the heating arrangement from other parts of the exhaust system.

Preferably, the reductant is supplied upstream of said heated portion of the exhaust conduit. Thereby the reductant may be heated directly at the heated portion. However, alternatively the reductant may be supplied downstream of said heated portion of the

exhaust conduit. Thereby the heated portion may heat exhaust passing said portion, upon which the reductant is heated by the exhaust gases.

Preferably, said portion of the exhaust conduit is a portion of a delimiting wall of the exhaust conduit and/or an element located inside a delimiting wall of the exhaust conduit. The element may be a structure arranged inside of the delimiting wall of the exhaust conduit, in the exhaust flow. However, the heated portion may in some embodiments be formed solely by the portion of the exhaust conduit delimiting wall. The electric conduit may extend in a longitudinal direction of the exhaust conduit along a part of the exhaust conduit, e.g. in a spiralling manner as exemplified below. It is understood that the heated portion of the exhaust conduit delimiting wall has substantially the same extension in the exhaust conduit longitudinal direction as the electric conduit. It is understood that the extension of the electric conduit in the exhaust conduit longitudinal direction may fully overlap the extension of the heated portion of the exhaust conduit delimiting wall in the exhaust conduit longitudinal direction.

The portion of the exhaust conduit that is provided with induction heating preferably comprises an electrically conductive or semi-conductive material. The material may be electrically resistive. Thus, the portion of the exhaust conduit that is provided with induction heating preferably comprises a material that is heated by an alternating magnetic field provided by the alternating current through the electric conduit. The alternating magnetic field may provide alternating electric currents, e.g. eddy currents, in the material which is heated by the electric resistance of the material. The portion of the exhaust conduit delimiting wall and/or the element located inside the exhaust conduit delimiting wall may comprise a magnetic material, preferably a ferromagnetic material, i.e. a material showing a significant response to a magnetic field, e.g. iron. Thus, the portion of the exhaust conduit that is provided with induction heating may comprise a permanent magnet or a ferromagnetic material, whereby in the latter case said portion may form a temporary magnet which will remain magnetized only as long as the magnetizing cause is present. Thereby, a large portion of the power of the current in the electric conduit may be transferred to heat in the portion of the exhaust conduit that is provided with induction heating. However, it is possible for the portion of the exhaust conduit that is provided with induction heating to be substantially non-magnetic, but nevertheless comprise an electrically conductive or semi-conductive material. In general, all materials with conducting- or semiconducting properties can be induction heated, e.g. stainless steel, A4

or non-magnetic inconel (austenitic) quality. In other words, portion of the exhaust conduit that is provided with induction heating may include a conductive or semi-conductive material, which in addition may be magnetic.

The heated element position inside the exhaust conduit wall creates conditions for heating a large part of the exhaust gas. Preferably the element located inside the exhaust conduit wall, herein also referred to as an inductively heatable element, is located in a position along the exhaust conduit being overlapped by the electric conduit. This allows for an energy efficient solution in that the distance between the electric conduit and said element may be minimized.

Preferably, the inductively heatable element, for some embodiments referred to as a magnetic element, is allowed to alter a flow of exhaust gases in the exhaust conduit. The alteration of the flow may include inducing turbulence to the flow. This may allow the reductant to thoroughly mix with the exhaust gases before reaching the catalyst. Thus, the method preferably comprises allowing the reductant to mix with the exhaust gases before reaching the catalyst.

In some embodiments, the exhaust gas treatment system comprises a mixer positioned inside the exhaust conduit wall, between the reductant supply means and the selective catalytic reduction catalyst for mixing the supplied reductant with the exhaust gas. In this way, the reductant may be mixed more homogenously with the exhaust gases, which creates conditions for an improved functionality of the NOx reduction. According to one example, the mixer may be formed by a swirl and/or turbulence inducing element.

The mixer may be integrated with the inductively heatable element or it may be separated from it. The inductively heatable element may form an integral part of the mixer, or it may be rigidly attached to the mixer. The mixer may be at least partly formed by a magnetic material and the electric conduit may be adapted for heating the mixer. In this way, a one-piece unit comprising both the mixing and magnetic function may be achieved, which may be beneficial in that the mixer, which is subjected to reductant deposit may be directly heated. Further, the one-piece unit may be advantageous from an assembly and/or service perspective.

A mixing zone may be formed between the reductant supply means and the catalyst.

In other words, inductive heating may be provided of a portion of the exhaust conduit, in a reductant mixing zone between the reductant supply means and the selective catalytic reduction catalyst. By arranging the inductively heatable element in one piece with the mixer, there may be a single element in the urea mixing zone, thereby creating conditions for reducing the resistance to the exhaust flow.

In some embodiments, there may be heating by induction of two spaced apart parts, namely the inductively heatable element and the mixer. In other words, a two-step heating process may be used, wherein the heating may be controlled separately and independently for the inductively heatable element and the mixer. Such separately controlled heating may advantageously increase adaptation to various operational states of the exhaust gas treatment system.

Preferably, the method comprises determining a rate of reductant consumption by the exhaust gas treatment process in the catalyst, wherein the supply of the reductant is controlled so as to provide a flow of reductant that is higher than the determined rate of reductant consumption. The supply of the reductant may be terminated. The steps of supplying a reductant so as to provide a flow of reductant that is higher than the determined rate of reductant consumption, and terminating the supply of the reductant, may be repeated.

Thus, reductant may be temporarily supplied upstream of the catalyst, simultaneously with heating the exhaust conduit portion, thereby heating a surface subjected to the reductant, the reductant being supplied to an extent that is higher than what is consumed by NOx in the exhaust gases. Thereby, excess ammonia formed by the reductant may be stored in the catalyst. Thereby a discontinuous and repeated reductant supply and heating of the exhaust conduit portion are provided. During each period of reductant supply, the amount of reductant stored in the catalyst is increased due to the flow of reductant supplied being higher than the determined rate of reductant consumption. This means that the SCR catalyst can operate on a temperature which is too low for urea thermolysis. Also, the discontinuous and repeated reductant supply and heating provides a process which is more energy efficient than a process with a continuous reductant supply and heating.

Embodiments of the method comprises starting the engine, and initiating the provision of the alternating current through the electric conduit simultaneously or at a predetermined

point in time before or after the engine start. Thereby, the method will provide an efficient exhaust gas treatment at engine cold start conditions. The induction heating provided by the alternating current may provide a very quick response in cases where the catalyst is cold and the reductant storage level therein is low. Reductant injection may be allowed to start only a few second after engine start.

Preferably, the method comprises determining the effect on the temperature in the exhaust conduit provided by the induction heating, and controlling the supply of the reductant in dependence on the determined temperature effect. Determining the temperature effect may include measuring the temperature by means of a sensor in the exhaust conduit, or calculating the temperature in the exhaust conduit based on other parameters and a computing model for the exhaust gas treatment system stored accessible to an electronic control unit arranged to control the method. Determining the temperature effect may comprise determining the temperature in the exhaust conduit downstream of said heated portion of the exhaust conduit. The method may comprise initiating the supply of reductant in dependence on whether the determined temperature in the exhaust conduit is above a predetermined temperature threshold value. Thereby, the reductant supply will be adapted to the catalyst temperature, and deposits caused by the reductant due to a relatively low temperature may be avoided. Also, the determined temperature may be used to identify an operational state of the engine system, e.g. a cold start situation, and further steps may be adapted to the operational state.

In some embodiments, the method comprises determining an amount of stored reductant in the catalyst. The provision of the alternating current through the electric conduit may be initiated in dependence on the determined stored reductant amount. For example, the provision of the alternating current may be initiated in dependence on whether the determined stored reductant amount is below a predetermined reductant amount threshold value. Also, the supply of the reductant may be controlled in dependence on the determined stored reductant amount. For example, the supply of reductant may be initiated in dependence on whether the determined stored reductant amount is below a predetermined reductant amount threshold value. In some embodiments, the reductant supply may be initiated after the initiation of the induction heating, in order to allow surfaces of the heated exhaust conduit portion to reach a temperature suitable for urea thermolysis. The amount, or flow, of supplied reductant may depend on e.g. the exhaust gas flow and/or the power of the alternating current for the induction heating. Further, the

reductant supply and the induction heating may be terminated after a predetermined time interval, or after indication that a sufficient amount of reductant is stored in the catalyst. Thereby, the NOx reduction process in the catalyst may be continued after the termination of the reductant supply and the induction heating. Determining the stored reductant amount may include calculating the stored reductant amount in the catalyst based on measures engine system parameters and a computing model for the exhaust gas treatment system stored accessible to an electronic control unit arranged to control the method.

In beneficial embodiments, the method may comprise supplying compressed air into the exhaust conduit upstream of the supply of the reductant into the exhaust conduit. This is a highly advantageous embodiment, e.g. where the compressed air is provided by a compressor is arranged to be driven by a device which is different from the internal combustion engine, e.g. an auxiliary device, such as an electric motor. The compressor may be solely dedicated to the supply of air into the exhaust conduit, or the compressor may be arranged to supply compressed air for other purposes as well, e.g. for an air conditioning system of a vehicle in which the engine system is provided.

The supply of compressed air into the exhaust conduit may be provided for example in an electric hybrid vehicle, during an engine shut-down, electric operation mode of the vehicle, for preheating the catalyst before engine start. Compressed air may be available due to an electrical compressor drive. The method may comprise determining a need to start the engine, and initiating the supply of compressed air and the provision of the alternating current through the electric conduit in dependence on the determined engine start need. Thereby, an air flow will be provided in the exhaust conduit, passing the heated exhaust conduit portion and the catalyst. This will provide an efficient heating of the catalyst when the engine is still shut down. Thereby, when the engine is started the catalyst may be available immediately for the exhaust treatment process.

Said benefits of the compressed air supply may be provided even where alternatives to inductive heating is provided, such as resistive heating. Thus, the objects are reached also with a method for controlling an exhaust gas treatment system arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit, characterized by supplying compressed air into the exhaust conduit. Thereby, where the exhaust gas treatment system comprises a catalyst provided in the exhaust

conduit, the method may comprise heating an exhaust gas in the exhaust conduit upstream of the catalyst and downstream of the compressed air supply into the exhaust conduit. Thereby, heating the exhaust gas may comprise providing an alternating current through an electric conduit located externally of the exhaust conduit, thereby providing induction heating of an portion of the exhaust conduit located upstream of the catalyst and downstream of the compressed air supply into the exhaust conduit. Alternatively, the heating may be provided by electric resistance. Where the catalyst is a selective catalytic reduction catalyst, the method may comprise supplying, into the exhaust conduit upstream of the heating of the exhaust gas and downstream of the compressed air supply into the exhaust conduit, a reductant for an exhaust gas treatment process in the catalyst.

The objects are also reached with a computer program according to claim 23, a computer readable medium according to claim 24, or a control unit according to claim 25.

The objects are also reached with an exhaust gas treatment system comprising an exhaust conduit, characterized in that the exhaust gas treatment system comprises an air compressor, the exhaust gas treatment system being arranged to supply air from the air compressor into the exhaust conduit. The exhaust gas treatment system may be arranged to supply air from the air compressor into the exhaust conduit by means of a conduit and a nozzle in the exhaust conduit. Similarly to embodiments of the method described above, such an air supply may be highly advantageous, e.g. in an electric hybrid vehicle, during an engine shut-down mode of the vehicle, for preheating the catalyst before engine start. When the engine is started the catalyst may be available immediately for the exhaust treatment process. It is understood that the exhaust gas treatment system may arranged to supply air from the air compressor into the exhaust conduit via an air conduit.

It should be noted that the exhaust gas treatment system being arranged to supply air from the air compressor into the exhaust conduit may also be provided also in a vehicle with a traditional drivetrain powered only by an internal combustion engine, e.g. for preheating the catalyst before engine start. The exhaust gas treatment system may comprise a catalyst provided in the exhaust conduit, downstream of the supply of air into the exhaust conduit. The exhaust gas treatment system may further comprise an arrangement for heating an exhaust gas in the exhaust conduit and/or a portion of the system, upstream of the catalyst and downstream of the supply of air into the exhaust conduit. The heating arrangement may be adapted for inductive heating and it may

comprise a heater positioned externally of the exhaust conduit. The catalyst may be a selective catalytic reduction catalyst, and the exhaust gas treatment system comprises a means for supplying a reductant into the exhaust conduit upstream of the catalyst and downstream of the supply of air into the exhaust conduit. Thereby, the engine system may be arranged to detect the need to start the engine, e.g. by detecting a request from an interface for a vehicle driver to start the engine, and the engine system may be arranged to initiate the supply of compressed air and the heating of the exhaust conduit portion in dependence on the determined engine start need.

The objects may also be achieved by an exhaust gas treatment system as claimed and described in PCT/EP2016/061082, incorporated herein by reference. Thus, the objects may be achieved by an exhaust gas treatment system comprising an exhaust passage, herein also referred to as an exhaust conduit, a selective catalytic reduction catalyst provided in the exhaust passage, a means for supplying a reductant into the exhaust passage upstream of the selective catalytic reduction catalyst for NOx reduction, and an arrangement for heating an exhaust gas in the exhaust passage and/or a portion of the system, characterized in that the heating arrangement is adapted for inductive heating and that it comprises a heater, e.g. an electric conduit, positioned externally of the exhaust passage and upstream of the selective catalytic reduction catalyst. In some embodiments, the heating arrangement comprises at least one first inductively heatable element, for certain embodiments referred to as a first magnetic element, arranged in such a way that it may be heated via induction by the heater. Such embodiments provide further conditions for localized heating of the specific surfaces, where deposits normally form. According to some embodiments, the heater is positioned between the reductant supply means and the selective catalytic reduction catalyst. In other words, the heating arrangement may be arranged for inductive heating of a portion of the system in a reductant mixing zone between the reductant supply means and the selective catalytic reduction catalyst.

In some embodiments, the first inductively heatable element has a main extension in a direction transverse to a longitudinal direction of the exhaust passage. The term “longitudinal direction” represents a main extension direction of the passage. In other words, the longitudinal direction represents a main exhaust flow direction. According to one example, the first inductively heatable element has a main extension in a direction perpendicular to the longitudinal direction of the exhaust passage. According to one

example, the first inductively heatable element is relatively thin and/or has its main extension in a plane. According to one example, the first inductively heatable element is arranged in contact with a wall of the exhaust passage. According to further example, the first inductively heatable element is static in relation to the passage wall. In other words, the first inductively heatable element is rigidly arranged in relation to the passage wall. For example, the first inductively heatable element is rigidly attached to the exhaust passage wall. According to a further embodiment, at least a part of a wall of the exhaust passage forms the first inductively heatable element.

According to a further embodiment, the exhaust treatment system comprises a mixer positioned inside the exhaust gas passage between the reductant supply means and the selective catalytic reduction catalyst for mixing the supplied reductant with the exhaust gas. According to one example, the mixer may be formed by a swirl and/or turbulence inducing element. According to one example, the mixer is arranged in contact with a wall of the exhaust passage. According to a further example, the mixer is static in relation to the passage wall. In other words, the mixer is rigidly arranged in relation to the passage wall. For example, the mixer is rigidly attached to the passage wall. According to a further embodiment, the first inductively heatable element forms an integral part of the mixer or is rigidly attached to the mixer. According to a further embodiment, the first inductively heatable element is located at a distance from the mixer. According to one alternative, the first inductively heatable element is located upstream of the mixer, wherein the exhaust gas may be heated before it reaches the mixer, wherein there is a reduced risk of deposit build up on the mixer. According to an alternative, the first inductively heatable element is located downstream of the mixer.

In some embodiments, the heating arrangement comprises a second heater and a second inductively heatable element, for certain embodiments referred to as a second magnetic element, associated to the second heater. The second heater may be positioned externally of the exhaust passage and between the reductant supply means and the selective catalytic reduction catalyst. Thus, the first and second heaters may be formed by different units, which is each designed and controlled for its respective purpose.

According to a further aspect, the invention regards an internal combustion engine system comprising an internal combustion engine and an exhaust gas treatment system according to any preceding embodiment positioned downstream of the internal

combustion engine for treating exhaust gases from the internal combustion engine. According to one embodiment, the internal combustion engine is arranged for providing power to the heater. According to a further aspect, the invention regards a vehicle comprising such an internal combustion engine system. The internal combustion engine may be adapted for providing motive power for propelling the vehicle.

Further advantages and advantageous features of the invention are disclosed in the following description and in the dependent claims.

BRIEF DESCRIPTION OF THE DRAWINGS

With reference to the appended drawings, below follows a more detailed description of embodiments of the invention cited as examples.

In the drawings:

Fig. 1 is a side view of a truck comprising an internal combustion engine with an exhaust gas treatment system,

Fig. 2 shows an embodiment of an internal combustion engine system comprising an internal combustion engine and an exhaust gas treatment system,

Fig. 3 – fig. 4 show sections of the exhaust gas treatment system with an embodiment of an inductively heatable element,

Fig. 5 is a block diagram depicting steps in a method of controlling the internal combustion engine system in fig. 2,

Fig. 6 is a block diagram depicting steps in a further method of controlling the internal combustion engine system in fig. 2,

Fig. 7 shows another embodiment of an internal combustion engine system comprising an internal combustion engine and an exhaust gas treatment system,

Fig. 8 is a block diagram depicting steps in a method of controlling the internal combustion engine system in fig. 7,

Fig. 9 shows a further embodiment of an exhaust gas treatment system,

Fig. 10 is a block diagram depicting steps in a method according to another embodiment of controlling an exhaust gas treatment system,

Fig. 11 – fig. 32 show inductively heatable elements according to various embodiments,

Fig. 33 and fig. 34 are schematic views of exhaust gas treatment systems according to different embodiments for treating exhaust gases from the engine in fig. 1,

Fig. 35 - fig. 36 show respective embodiments of an electrical device adapted for supplying power to a heater for an exhaust gas treatment system, and

Fig. 37 – fig. 40 show different embodiments of an internal combustion engine system comprising an internal combustion engine and an exhaust gas treatment system.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS OF THE INVENTION

Fig. 1 shows a vehicle 2 in the form of a truck in a partly cut side view. The vehicle 2 has an internal combustion engine system 4 for driving the vehicle 2. The internal combustion engine system 4 comprises an internal combustion engine 6 in the form of a diesel engine.

Fig. 2 shows a first embodiment of an internal combustion engine system comprising the internal combustion engine 6 and an exhaust gas treatment system 8 for treating exhaust gases from the engine 6. The exhaust gas treatment system 8 comprises an exhaust passage 10, or herein also referred to as an exhaust conduit 10 or an exhaust gas line, in the form of a tube for conveying exhaust gases, see arrow 9, discharged from the engine 6.

The exhaust gas treatment system 8 further comprises a selective catalytic reduction (SCR) catalyst 12 provided in the exhaust passage 10 for selectively reducing NOx

contained in the exhaust gas. The SCR catalyst 12 forms a body with an external shape and size matched to an internal shape and size of the exhaust passage so that no, or at least very small amount of, exhaust gases may pass the SCR without being treated. The SCR catalyst 12 may be made from a ceramic materials used as a carrier, such as titanium oxide, and active catalytic components are usually either oxides of base metals (such as vanadium, molybdenum and tungsten), zeolites, or various precious metals. According to one example, the SCR catalyst 12 may use an ammonia adsorption type Fe zeolite having a high NOx reducing rate under low temperature. Further, the SCR catalyst 12 may be formed by a brick of a porous construction. The porosity is what gives the catalyst the high surface area essential for reduction of NOx. Further, the selective catalytic reduction catalyst may be coated on a flow-through monolith.

The exhaust gas treatment system 8 comprises an oxidation catalyst (DOC) 34 having function of oxidizing carbon monoxide (CO), hydrocarbons (HC) and nitrogen monoxide (NO) contained in the exhaust gas and diesel fuel injected into the exhaust gas. The DOC 34 uses precious metals such as platinum and/or palladium. The exhaust gas treatment system 32 further comprises diesel particulate filter (DPF) 36 disposed downstream of the DOC 34 with respect to the flowing direction of exhaust gas for capturing and collecting particulate matter contained in exhaust gas. The DPF may also have catalytic functions for oxidising. The selective catalytic reduction (SCR) catalyst 12 is disposed downstream of the DPF 36 with respect to the flowing direction of the exhaust gas.

The exhaust gas treatment system 8 further comprises reductant supply means, or means 14 for supplying a reductant into the exhaust passage 10 upstream of the SCR catalyst 12 for NOx reduction. The reductant may be in liquid form. Further, the reductant may be sprayed into the exhaust gas passage. The reductant may be formed by a urea solution. The reductant may be automotive-grade urea. The reductant sets off a chemical reaction that converts nitrogen oxides into nitrogen, water and tiny amounts of carbon dioxide (CO2). The reductant is composed of purified water and automotive grade aqueous urea. The reductant could also be of any other type of ammonia carrier, e.g. ammonia carbamate, isocyanate, and guanidinium formate or similar.

The reductant supply means 14 may be formed by an injector positioned in the exhaust gas passage. The injector 14 is located downstream of the DPF 36 and upstream of the SCR catalyst 12. A zone in the exhaust conduit 20 between the injector and the catalyst

12 is herein referred to as a urea mixing zone 22. The internal combustion engine system further comprises a storage vessel 38 for the reductant and a pump 40 for pumping the reductant from the vessel 38 to the injector 14 inside the exhaust gas passage 10.

The exhaust gas treatment system 8 further comprises an arrangement 16 for heating a portion of the system and/or the exhaust gas. More specifically, the heating arrangement 16 is adapted for inductive heating. The heating arrangement 16 comprises a heater 20 positioned externally of the exhaust passage 10 and between the urea supply means 14 and the SCR catalyst 12. The heater 20 may be formed by a coil in the form of an electric conduit 20 or a conductor located externally of the exhaust conduit 10, more specifically arranged around the exhaust gas passage, to create an inductor.

The internal combustion engine system further comprises an electrical device 100, described further below, adapted for supplying power to the heater 20. The electrical device 100 is arranged to provide an alternating current through the electric conduit 20, thereby providing induction heating of said portion of the exhaust conduit 10.

Further, according to the shown example, the heating arrangement 16 comprises an element in the form of a first inductively heatable element 118 positioned inside a delimiting wall 101 of the exhaust passage 10. The inductively heatable element 118 forms a part of said portion of the exhaust conduit 10 arranged to be heated by the induction heating by the electric conduit 20. Further, the inductively heatable element 118 is located in a position along the exhaust passage 10 which is overlapped by the heater 20.

The inductively heatable element 118 comprises an electrically conductive or semi-conductive material. Said material also has magnetic properties. The inductively heatable element 118 may be designed with a core of a metallic material, such as iron, and an external layer of anti-corrosive and/or catalytic material. The inductively heatable element may but does not need to form a permanent magnet. The inductively heatable element is preferably ferromagnetic. Preferably the magnetic element may form a temporary magnet which will remain magnetized only as long as the magnetizing cause is present. In some embodiments, the inductively heatable element 118 is substantially non-magnetic, but comprises an electrically conductive or semi-conductive material.

The inductively heatable element 118 may function as a vaporizer for vaporizing the liquid reductant sprayed into the exhaust gas. More specifically, urea droplets of the reductant are subjected to vaporization and form ammonia gas via a thermolysis and hydrolysis reaction. In other words, the urea decomposes to form ammonia which reacts with the nitrogen oxides in the SCR catalytic converter to form nitrogen and water. As a result of improved vaporization of the reductant, the desired chemical reaction in the SCR can take place with increased efficiency, so a higher NOx conversion rate and thus lower NOx emissions can take place.

The inductively heatable element 118 is adapted for heating the exhaust gas when heated via induction by means of the heater 20. Heating of the exhaust gas is advantageous in certain operational states of the engine, in which the exhaust gases are so cold that they otherwise may not decompose the urea and there is a risk of the urea forming deposits within the exhaust gas passage.

The electric conduit 20 extends along a portion of a delimiting wall 101 of the exhaust conduit 10. In some embodiments, the portion of the exhaust conduit 10 provided with induction heating by means of the electric conduit 20 may include said portion of the wall 101. In some embodiments, no inductively heatable element may be provided in the exhaust conduit 10, and the electric conduit 20 may be arranged to provide induction heating of said portion of the exhaust conduit wall 101 only.

The engine system further comprises an electronic control unit 300. The control unit 300 is arranged to control the control pump 40 for pumping the reductant, and the electrical device 100 for providing an alternating current through the electric conduit 20.

A first NOx sensor 301 is provided in the exhaust passage 10 upstream of the SCR catalyst 12 with respect to the flowing direction of exhaust gases. The first NOx sensor 301 is located downstream of the DPF 36. The control unit 300 is arranged to receive signals from the first NOx sensor 301 for determining the amount of NOx contained in exhaust gases upstream of the SCR catalyst 12. A second NOx sensor 302 is provided in the exhaust passage 10 downstream of the SCR catalyst 12 with respect to the flowing direction of exhaust gases. The control unit 300 is arranged to receive signals from the second NOx sensor 302 for determining the amount of NOx contained in exhaust gases downstream of the SCR catalyst 12.

Further, a first temperature sensor 303 is provided in the exhaust passage 10 upstream of the electric conduit 20 of the heating arrangement 16. The first temperature sensor 303 is located downstream of the DPF 36. The control unit 300 is arranged to receive signals from the first temperature sensor 303 for determining the temperature upstream of the heating arrangement 16. A second temperature sensor 304 is provided in the exhaust passage 10 in the SCR catalyst 12, downstream of the electric conduit 20 of the heating arrangement 16. The control unit 300 is arranged to receive signals from the second temperature sensor 304 for determining the temperature in the SCR catalyst 12.

In some embodiments, the second temperature sensor 304 may be located in the exhaust conduit, between the electric conduit 20 of the heating arrangement 16 and the SCR catalyst 12. The second temperature sensor 304 may alternatively be located downstream of the SCR catalyst 12. In some embodiments, the temperature in the SCR catalyst 12 may be calculated in real time based on for example the exhaust gas flow, the temperature upstream of the heating arrangement 16, and the power provided to the electric conduit 20.

Fig. 3 shows a section of the exhaust gas system in the urea mixing zone 22 with the inductively heatable element 118 in a cross section view. Fig. 4 shows the section of the exhaust gas system according to fig. 3 in a partly cut perspective view.

The inductively heatable element 118 is annular and in the form of a tubular body, which creates conditions for little or no increase in flow resistance. The inductively heatable element 118 is arranged inside the wall 101 of the exhaust passage 10. The inductively heatable element 118 is designed with a cross sectional shape corresponding to an inner cross section shape of the exhaust passage wall 101 but with a smaller dimension than the exhaust passage wall 101. In the embodiment shown, the exhaust passage wall 101 has a circular cross section shape and the inductively heatable element 118 also has a circular cross section shape. A centre axis of the exhaust passage wall 101 is in parallel with and in this case commensurate with a centre axis of the annular inductively heatable element 118. Further, the inductively heatable element 118 is arranged inside the wall 101 of the exhaust passage 10 so that a radial gap is formed between an outer wall surface of the annular inductively heatable element 118 and an inner surface of the exhaust passage wall 101. The inductively heatable element 118 has an extent in the longitudinal direction

of the exhaust gas passage sufficient for said heating. According to one example, the inductively heatable element 118 is formed by a tubular sheet metal body. According to a further example, a plurality of tubular bodies is arranged side-by-side in parallel with a longitudinal direction of the exhaust gas passage. Such a plurality of tubular bodies provides for a larger heating (and vaporization) surface.

Further, the annular inductively heatable element 118 is positioned inside the wall 101 of the exhaust passage 10 via positioning members 26, or struts, connecting the annular inductively heatable element 118 radially with the exhaust passage wall 101. Thus, the metallic element is secured within the wall 101 of the exhaust passage. According to the shown example, the positioning members 26 of the inductively heatable element are welded to an internal surface of the exhaust passage. However, there may be other ways of securing the inductively heatable element inside the exhaust passage wall, for example allowing a relative radial movement between the inductively heatable element and the exhaust passage wall for allowing different thermal expansion of the inductively heatable element in relation to the exhaust passage. For example, the exhaust passage may comprise a plurality of circumferentially spaced openings for receiving the struts 26 and allowing a radial relative movement. According to one alternative, the inductively heatable element may be elastically braced in relation to the exhaust passage wall or secured via a form-fit or press-fit.

A thermal insulation layer 24 is arranged around the exhaust passage 10. More specifically, the thermal insulation layer 24 is positioned between the exhaust passage 10 and the heater 20. Further, the thermal insulation layer 24 is continuous in a circumferential direction of the exhaust passage 10. Further, the thermal insulation layer 24 has an extent in a longitudinal direction of the exhaust passage 10 substantially matching at least an extent of the heater 20 in the longitudinal direction of the exhaust passage 10. According to an alternative, the system may not be provided with any such a thermal insulation layer.

Reference is made to fig. 5 depicting a method according to an embodiment of the invention of controlling the exhaust gas treatment system 8 in fig. 2. During operation of the engine system, a rate of reductant consumption by the exhaust gas treatment process in the catalyst 12 is determined S1. The rate of reductant consumption may be determined S1 based on signals from the first and second NOx sensors 301, 302

indicating the rate of NOx conversion in the catalyst 12, from which the reductant consumption rate can be determined.

Also, an amount of stored reductant in the catalyst 12 is determined S2. The amount of stored reductant may be determined S2 based on the amount of reductant that has been injected by the injector 14 and an integration of the determined S1 reductant consumption rate. The determined stored reductant amount is compared S3 to a predetermined reductant amount threshold value. If the determined stored reductant amount is higher than the threshold value, the step of determining S2 the amount of stored reductant in the catalyst 12 is repeated.

If the determined stored reductant amount is lower than the reductant amount threshold value, an alternating current is provided S4 through the electric conduit 20 so as to provide induction heating of the inductively heatable element 118 and the exhaust conduit wall 101 at the electric conduit 20.

Further, if the determined stored reductant amount is lower than the reductant amount threshold value, reductant for an exhaust gas treatment process in the catalyst 12 is supplied S5 by means of the injector 14 into the exhaust conduit 10 upstream of the inductively heatable element 118. The supply S5 of the reductant is controlled so as to provide a flow of reductant that is higher than the determined S1 rate of reductant consumption. By means of the heated inductively heatable element 118 the injected reductant is decomposed to form ammonia. It should be noted that where the exhaust gases have a temperature which is above a threshold temperature for the decomposition of the reductant, e.g. 200ºC where the reductant is urea, reductant may be injected without any heating by means of the heating arrangement.

After a predetermined amount of time from the initiation of the supply S5 of reductant, the amount of stored reductant in the catalyst 12 is determined S6 again. The determined stored reductant amount is compared S7 to a further predetermined reductant amount threshold value. If the determined stored reductant amount is lower than the further threshold value, the supply S5 of reductant is continued. If the determined stored reductant amount is higher than the further reductant amount threshold value, the supply of the reductant is terminated S8, and the induction heating is terminated S9 as well.

This embodiment of the method comprises repeating the steps of determining S1 a rate of reductant consumption by the exhaust gas treatment process in the catalyst 12, determining S2 an amount of stored reductant in the catalyst 12, comparing S3 the determined stored reductant amount to a predetermined reductant amount threshold value, providing S4, if the determined stored reductant amount is lower than the reductant amount threshold value, induction heating of the inductively heatable element 118 and the exhaust conduit wall 101, and supplying S5 reductant for the exhaust gas treatment process in the catalyst 12. Thereby discontinuous and repeated reductant supply and heating of the inductively heatable element 118 are provided. During each period of reductant supply, the amount of reductant stored in the catalyst 12 is increased due to the flow of reductant supplied being higher than the determined S1 rate of reductant consumption. This means that the SCR catalyst 12 can operate on a temperature which is too low for urea thermolysis, but which is high enough for the process of reducing NOx. The discontinuous and repeated heating of the inductively heatable element 118 may, compared to a continuous heating, reduce the fuel consumption of the vehicle. More specifically, avoiding continuous heating of the inductively heatable element will reduce the power consumption of the heating arrangement 16 and hence it will reduce the fuel to electric power conversion of the vehicle.

Reference is made to fig. 6 depicting steps of controlling the exhaust gas treatment system 8 in fig. 2 during a cold start of the engine system. Thereby, the engine is started S101. Further, the provision of the alternating current through the electric conduit 20 is initiated S102, so as to provide induction heating of the inductively heatable element 118. The heating initiation S102 may be done simultaneously with or at a predetermined point in time before or after the engine start S101.

Subsequently, by means of the second temperature sensor 304, the temperature in the SCR catalyst 12 is determined S103, so as to determine the effect on the temperature in the exhaust conduit 10 provided by the induction heating. The determined temperature is compared S104 to a predetermined threshold temperature value. If the determined temperature is lower than the threshold value, the determination S103 of the temperature in the SCR catalyst 12 is repeated.

If the determined temperature is higher than the threshold value, the amount of stored reductant in the catalyst 12 is determined S105. The determined stored reductant amount

is compared S106 to a predetermined reductant amount threshold value. If the determined stored reductant amount is higher than the reductant amount threshold value, the determination S105 of the amount of stored reductant in the catalyst 12 is repeated.

If the determined stored reductant amount is lower than the reductant amount threshold value, reductant for an exhaust gas treatment process in the catalyst 12 is supplied S107 by means of the injector 14 into the exhaust conduit 10 upstream of the inductively heatable element 118. The stored reductant amount is repeatedly determined simultaneously with the supply S107 of the reductant. If the stored reductant amount is determined to be relatively low, the flow of reductant is controlled to be higher than if the stored reductant amount is determined to be relatively high.

Further, the flow of reductant through the injector 14 is controlled in dependence on the catalyst temperature. The catalyst temperature is repeatedly determined simultaneously with the supply S107 of the reductant. If the catalyst temperature is determined to be relatively low, the flow of reductant is controlled to be lower than if the stored reductant amount is determined to be relatively high. Thereby, the reductant supply will be adapted to the catalyst temperature, and deposits caused by the reductant due to a relatively low temperature may be avoided.

Fig. 7 shows an engine system according to an alternative embodiment of the invention. The engine system shares features with the engine system described above with reference to fig. 2, but differs therefrom as follows:

The engine system provides an electric hybrid drivetrain, and comprises in addition to the engine 6 a motor-generator 601, herein also referred to as a motor 601. The engine 6 is mechanically connectable to a rotor of the motor 601 via a clutch 602, and the motor 601 is mechanically connected to a transmission 603. The transmission 603 is mechanically connected, via a cardan shaft, a wheel axle and a differential gear, to two wheels 604 of the vehicle for its propulsion.

The engine system also comprises an electric energy storage arrangement in the form of a battery pack 605. The battery pack 605 is electrically connected to the motor 601 via an inverter 606.

The engine system further comprises an air compressor 400, and an air conduit 401 and an air nozzle 402 arranged to supply air from the air compressor 400 into the exhaust conduit 10, upstream of the electric conduit 20 of the heating arrangement 16 and upstream of the reductant injector 14. The air nozzle is located downstream of the DPF 36. The air compressor 400 comprises an air inlet 404. An air valve 405 is arranged to control the flow through the air conduit 401. The air compressor is arranged to be driven by an electric compressor motor 403. The compressor motor is arranged to be powered by the battery pack 605. The compressor 400 is further arranged to provide compressed air to other systems in the vehicle, such as an air conditioning system (not shown).

The control unit 300 is arranged to send control signals to the compressor motor 403 and the air valve 405. The control unit 300 is also arranged to send and receive control signals from each of the engine 6, the clutch 602, the motor 601, the transmission 603 and the battery pack 605.

As is known per se, the hybrid drivetrain is arranged to operate in a mode in which the engine 6 is assisting in providing vehicle propulsion, and the hybrid drivetrain is also arranged operate in an electric mode in which the engine 6 is shut down, and the vehicle propulsion is provided by means of the motor 601 only.

Reference is made to fig. 8 depicting steps in a method for controlling the engine system in fig. 7. The control unit 300 is arranged to determine S201, when the engine system is operating in the electric mode, whether the engine 6 needs to be started. Reasons for starting the engine 6 may include that the engine is needed to assist in providing vehicle propulsion to meet a torque request of the engine system, or that a state of charge of the battery pack 605 below a threshold for supplying power to the motor 601.

Upon determining that the engine 6 needs to be started, the temperature of the SCR catalyst 12 is determined, and it is determined S202 whether the catalyst temperature is above a predetermined temperature threshold value. If the temperature is above the threshold value, the engine is started S207 without any preceding auxiliary heating process since the catalyst 12 is warm enough for supporting its exhaust treatment process. Where the reductant is urea, the threshold value may be a threshold value for the decomposition of the urea to ammonia, e.g. approximately 200ºC. Thus, even if the catalyst temperature is above a further threshold temperature for using the ammonia for

the reduction of NOx, e.g. 160ºC, any injected urea may need heating for the decomposition or thermolysis of the urea if the temperature is below the decomposition threshold temperature.

If the catalyst temperature is below the threshold value, an alternating current is provided in the electric conduit 20 so as to heat S203 by induction the inductively heatable element 118. Also, if the catalyst temperature is below the threshold value, the compressor motor 403 and the air valve 405 are controlled so as to initiate the supply S204 of compressed air by means of the air nozzle 402 into the exhaust conduit 10. Thereby, an air flow will be provided in the exhaust conduit 10, passing the heated inductively heatable element and the catalyst 12. This will provide an efficient heating of the catalyst when the engine is still shut down. Thereby, when the engine is started the catalyst 12 may be available immediately for the exhaust treatment process.

During the heating and the air supply the temperature of the SCR catalyst 12 is determined, and it is determined S205 whether the catalyst temperature is above a predetermined temperature threshold value. If the temperature is below the threshold value, the heating and the air supply are continued and the catalyst temperature is repeated. If the temperature is below the threshold value, the air supply and the induction heating are terminated S206, and the engine is started S207.

The supply of air into the exhaust conduit has been described in an engine system with a hybrid drivetrain. However, it should be noted that the method described with reference to fig. 8 may be carried out also in a non-hybrid engine system, such as the one depicted in fig. 2, provided with an air compressor 400 (fig. 7) arranged to be driven with an auxiliary power supply device such as an electric motor.

Fig. 9 shows an exhaust gas treatment system 8 according to another embodiment of the invention. The system comprises an exhaust conduit 10, adapted to receive exhaust gases from an internal combustion engine (not shown), and an air compressor 400 with an air inlet 404. The exhaust gas treatment system is arranged to supply, by means of an air conduit 401 and an air nozzle 402, air from the air compressor 400 into the exhaust conduit 10. The air compressor may be driven in any suitable manner, e.g. by an electric motor or by the engine via a belt drive.

Fig. 10 depicts steps in a method according to a further embodiment of the invention. The method controls an exhaust gas treatment system arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit, and a selective catalytic reduction catalyst provided in the exhaust conduit. The method comprises providing S4 an alternating current through an electric conduit located externally of the exhaust conduit, thereby providing induction heating of a portion of the exhaust conduit located upstream of the catalyst, and supplying S5, into the exhaust conduit upstream of said portion of the exhaust conduit, a reductant for an exhaust gas treatment process in the catalyst.

Above an exhaust gas treatment system with a heating arrangement comprising a inductively heatable element 118 was described with reference to fig. 2 – fig. 4. Below, inductively heatable elements of heating arrangements of alternative embodiments of the invention will be described with reference to fig. 11 – fig. 32. As exemplified below, in some embodiments, the inductively heatable element may by its shape and location inside the delimiting wall 101 of the exhaust conduit 10 be arranged to alter the flow of exhaust gases in the exhaust conduit.

Fig. 11 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 218 according to a second embodiment in a cross section view. Fig. 12 shows the section of the exhaust gas system according to fig. 11 in a partly cut perspective view.

The inductively heatable element 218 is designed for forming a mixer for mixing the urea with the exhaust gases in the urea mixing zone 22 between the urea supply means 14 and the SCR catalyst 12. More specifically, the inductively heatable element 218 provides for a homogeneous mixing of the vaporized reducing agent with the exhaust gas. Thus, the mixer and the inductively heatable element is formed by a one-piece unit 218. In other words, the mixer is designed for mixing the urea with the exhaust gases and comprising a magnetic material sufficient for the induction heating.

The inductively heatable element 218 forms a body with a shape and size matched to an internal shape and size of the exhaust passage 10 so that the urea is mixed with the exhaust gases to a great extent. According to one example, an external periphery of the

inductively heatable element 218 is in close vicinity of or in contact with an inner surface of the wall 101 of the exhaust passage 10.

The inductively heatable element 218 has such a design that a main extension of the inductively heatable element 218 is in a direction transverse to the longitudinal direction of the exhaust passage. More specifically, the inductively heatable element main extension is in a direction perpendicular to the longitudinal direction of the exhaust passage. Further, the inductively heatable element forms a relatively thin structure (small extension in the longitudinal direction of the exhaust passage).

The inductively heatable element 218 comprises at least one vane or blade member 220. More specifically, the inductively heatable element 218 comprises a plurality of such vanes, or blades. According to the shown example, the inductively heatable element 218 is of a propeller like structure, wherein the plurality of vanes is connected to a central hub 222. More specifically, the inductively heatable element comprises four circumferentially evenly spaced vanes 220. The vanes 220 are inclined in relation to the longitudinal direction of the exhaust passage 10 for creating a swirl of the exhaust gas. The tip of the vanes is in contact with the wall 101 of the exhaust passage for securing the inductively heatable element inside the wall 101.

Fig. 13 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 318 according to a third embodiment in a cross section view. Fig. 14 shows the section of the exhaust gas system according to fig. 13 in a partly cut perspective view.

The inductively heatable element 318 comprises at least one plate shaped member 320 turned or twisted along the longitudinal direction of the exhaust passage. More specifically, the inductively heatable element 318 comprises a plurality of such twisted plate shaped members 320. The plate shaped member 320 has an extension in the longitudinal direction of the exhaust passage, which is constant in the radial direction of the exhaust passage. More specifically, the plate shaped member 320 has a rectangular shape. According to the shown example, the inductively heatable element 318 is of an impeller like structure, wherein the plurality of plate shaped members is connected in a central hub 322. More specifically, the inductively heatable element comprises eight circumferentially evenly spaced plate shaped members 320. The tip of the plate shaped

members is in contact with the wall 101 of the exhaust passage for securing the inductively heatable element inside the wall 101 of the exhaust passage.

Fig. 15 shows a section of the exhaust gas system in the urea mixing zone 22 with the inductively heatable element 418 according to a fourth embodiment in a cross section view. Fig. 16 shows the section of the exhaust gas system according to fig. 15 in a partly cut perspective view.

The inductively heatable element 418 comprises at least one vane 420 being of a similar character as the propeller-like design in fig. 11 and fig. 12 but with the difference that the plate vanes 420 are connected along their outer periphery to the wall 101 of the exhaust passage 10 instead of to a central hub. More specifically, the vanes 420 ends a distance from a centre axis of the exhaust passage 10, thereby leaving a central free space 422. In other words, the inductively heatable element 418 according to fig. 15 and fig. 16 is a type of inverted design in relation to the inductively heatable element 118 in fig. 11 and fig. 12.

Fig. 17 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 518 according to a fifth embodiment in a cross section view. Fig. 18 shows the section of the exhaust gas system according to fig. 17 in a partly cut perspective view.

The inductively heatable element 518 forms a wall structure defining axial openings. More specifically, the wall structure comprises a plurality of walls 520,522 with different extension directions. More specifically, the wall structure comprises a plurality of first parallel walls 520 with a first extension direction and a plurality of second parallel walls 522 with a second extension direction. More specifically, the second walls 522 extend perpendicular to the first walls 520 forming a plurality of openings with a rectangular cross section shape. According to an alternative, the first walls extend in an inclined manner in relation to the second walls. Further, the wall structure extends over the complete inner cross section of the delimiting wall 101 of the exhaust passage 10. Further, the wall structure has an extension in the longitudinal direction of the exhaust passage 10. The longitudinal extension of the wall structure is at least twice the distance between adjacent walls in the wall structure. The longitudinal extension of the wall structure is associated to the available surface area which in turn is related to a required power.

Fig. 19 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 618 according to a sixth embodiment in a cross section view. Fig. 20 shows the section of the exhaust gas system according to fig. 19 in a partly cut perspective view. Fig. 21 shows the inductively heatable element according to fig. 19 in a perspective view from a position downstream of the inductively heatable element.

The inductively heatable element 618 forms a plate-shaped member with a main extension in a plane transverse to the longitudinal direction of the exhaust passage. More specifically, the plate-shaped member has a main extension in a plane perpendicular to the longitudinal direction of the exhaust passage 10. The plate-shaped member is perforated with openings. The openings have a rectangular shape, but may have any other geometrical shape, such as circular or other polygonal shape. More specifically, the openings are formed by cutting out a portion 620 of the plate-shaped member along a part of the profile of the opening while leaving a part of the profile, wherein the cut out portion is folded from the extension plane of the plate-shaped member. More specifically, the through holes have been cut out from the plate by cutting along three sides and folding the rectangular material along the fourth side. More specifically, the cut out portions 620 may extend at an angle in relation to the extension plane of the plate-shaped member. Further, the inductively heatable element 618 comprises a plurality of circumferentially spaced tabs 622 arranged at a periphery of the plate-shaped member for securing the inductively heatable element to wall 101 of the exhaust passage. More specifically, the tabs extend in parallel with the longitudinal direction of the exhaust passage.

Fig. 22 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 718 according to a seventh embodiment in a cross section view. Fig. 23 shows the section of the exhaust gas system according to fig. 22 in a partly cut perspective view.

The inductively heatable element 718 comprises a plurality of spaced parallel walls 720. The walls 720 have a main extension direction transverse to the longitudinal direction of the exhaust passage and a secondary extension direction in parallel with the longitudinal direction of the exhaust passage. A plurality of wall elements 722,724 are arranged between the walls 720 and rigidly attached to the walls 720. The wall elements 722,724 are rectangular. The wall elements 722, 724 are arranged in a spaced relationship in the main extension direction of the walls 720. A plurality of first wall elements 722 are

arranged in a first space between two adjacent walls and a plurality of second wall elements 724 are arranged in a second space between two adjacent walls, wherein the first wall elements 722 and the second wall elements 724 have different extension directions.

Fig. 24 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 818 according to an eighth embodiment in a cross section view. Fig. 25 shows the section of the exhaust gas system according to fig. 24 in a partly cut perspective view.

The inductively heatable element 818 comprises a wall 820 of a helical shape for guiding the exhaust gas. An outer edge 822 of the wall 820 is adjacent to an inner surface of the delimiting wall 101 of the exhaust gas passage 10 and an inner edge 824 of the wall 720 is at a distance from a centre axis of the exhaust passage. The wall 820 forms at least half a turn, preferably one complete turn and in the shown example two complete turns.

Fig. 26 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 918 according to an ninth embodiment in a cross section view. Fig. 27 shows the section of the exhaust gas system according to fig. 26 in a partly cut perspective view.

The inductively heatable element 918 forms a body 920 with an opening structure extending through the body 920. The opening structure comprises a plurality of openings. In the shown example, the openings are arranged in a plurality of parallel rows. Further, the openings have a polygonal cross sectional shape and more specifically a rectangular cross sectional shape. According to an alternative, or in combination, the openings may have the cross sectional shape of a square, triangle, star or any other conceivable shape.

Fig. 28 shows a section of the exhaust gas system in the urea mixing zone 22 with a inductively heatable element 1018 according to a tenth embodiment in a partly cut perspective view. In this embodiment, at least a part 1018 of the wall 101 of the exhaust passage 10 forms the inductively heatable element. According to the shown embodiment, the magnetic wall part 1018 is continuous in a circumferential direction of the exhaust passage wall 101. According to an alternative, the magnetic wall part is discontinuous in a circumferential direction of the exhaust passage. Further, according to the shown

embodiment, the magnetic wall part 1018 is formed by a discrete portion with a different magnetic property than the adjacent portions 10a, 10b of the exhaust passage. According to an alternative, the complete exhaust passage wall may be magnetic. According to a further alternative, the exhaust passage wall 101 may be formed by a material with no or low magnetic properties and be at least partly coated with a magnetic material.

Fig. 29 shows an alternative arrangement of the propeller-like inductively heatable element 218 according to the second embodiment shown in fig. 11 and fig. 12. The inductively heatable element and/or the exhaust passage is arranged with a mating structure for securing the position of the inductively heatable element in the longitudinal direction of the exhaust passage. More specifically, an inner surface of the wall 101 of the exhaust passage has a step 10a forming a support surface for the inductively heatable element 218. The support surface 10a is in this example formed circumferentially around the exhaust passage by means of a transition between two parts 10b, 10c of the exhaust passage wall 101 having different internal diameters.

Fig. 30 shows the propeller-like inductively heatable element 218 according to the second embodiment shown in fig. 11 and fig. 12 in a front view. Fig. 31 shows a cross section view of one of the vanes 220. The vane 220 has an airfoil shape. The vane 220 has a core 222 of a first material. Further, the vane 220 has a coating 224 of a second material. According to this example, the first material is magnetic and preferably ferromagnetic. The first material is metallic according to one example made of iron. The second material comprises an anticorrosion and/or catalytic material.

Fig. 32 shows an alternative design of a propeller-like inductively heatable element 218´ according to the second embodiment shown in fig. 11 and fig. 12 in a front view. The propeller-like inductively heatable element 218´ has a core 222` of a first material. Further, the propeller-like inductively heatable element 218´ is partially coated with a coating 224` of a second material. In other words, the propeller-like inductively heatable element 218´ comprises at least one and preferably a plurality of coated sections 224`. In this example, each vane 220` comprises at least one and preferably a plurality of coated sections 224`. According to this example, the first material is non-magnetic while the second material being magnetic and preferably ferromagnetic. The second material is metallic and according to one example is made of stainless steel. Such a design of the element with a core and coating is of course possible for any one of the other described examples.

Fig. 33 is a schematic view of an exhaust gas treatment system 8´, which is an alternative to the exhaust gas treatment system in fig. 2, for treating exhaust gases from the engine 6 in fig. 1. For ease of presentation, only the main differences with the system in fig. 2 will be disclosed below. The magnetic properties and the mixing properties are here divided in separate units 118a, 218 (first and second inductively heatable elements) arranged spaced in the longitudinal direction of the exhaust passage. More specifically, the system 8´ comprises a first inductively heatable element 118a, which forms part of an induction heating arrangement 16´. The first inductively heatable element 118a may be formed by the tubular member described above in connection with fig. 3 and fig. 4. The system 8´ further comprises swirl or turbulence inducing element 218. The turbulence inducing element 218 may be formed by the propeller-like element described above in connection with fig. 11 and fig. 12. According to the shown example, the propeller-like element 218 has magnetic properties and is associated to the inductive heating arrangement 16` for a second heating, wherein the propeller-like element 218 forms the second inductively heatable element. According to an alternative, the propeller-like element 218 may not be associated to any inductive heating arrangement, wherein there is no requirement on any magnetic properties of the propeller-like element 218.

According to a further alternative (not shown), the inductively heatable element may be located in close vicinity of the SCR catalyst 12 for heating the selective catalytic reduction catalyst. The inductively heatable element may form a grid or lattice structure. The grid structure may be designed so as to match a cross section of the porous structure of the SCR catalyst so that the cross bars in the grid structure covers a surface of the SCR catalyst facing the exhaust flow.

Fig. 34 is a schematic view of an exhaust gas treatment system which is an alternative to the system in fig. 33. For ease of presentation, here only a main difference with the system in fig. 33 is described: The inductively heatable element 118b and its associated heater (coil) 20'a is positioned between a oxidation catalyst (DOC) 34 and the urea supply means 14.

Fig. 35 shows a first embodiment of the electrical device 100 adapted for supplying power to the heater 20 for heating the inductively heatable element within the exhaust passage wall 101. The electrical device 100 comprises a source 102 of electrical power in the form

of a battery or other electrical energy storage means. The battery may be a traction battery for a hybrid powertrain. A DC/DC converter 104 is operatively connected to the traction battery 102. Further, a DC/AC converter 106 is operatively connected between the DC/DC converter 104 and the heater 20. According to an alternative, a further DC/DC converter may be operatively connected between the DC/DC converter 104 and the DC/AC converter 106 in order to step down the traction battery voltage to a lower voltage level.

Fig. 36 shows a second embodiment of an electrical device 100 adapted for supplying power to the heater 20 for heating the inductively heatable element within the exhaust passage wall 101 in an application of a conventional drivetrain. The engine 6 forms the power source. Further, the electrical device 100 comprises conversion units for converting chemical energy to electrical energy. More specifically, the electrical device 100 is operatively connected to the engine 6 and comprises in series an electrical machine 202, an AC/DC converter 204 (or DC/DC converter), a battery 206 and a DC/AC converter 208.

Fig. 37 shows a further embodiment of an internal combustion engine system 30 comprising the internal combustion engine 6 and an exhaust gas treatment system 32. For ease of presentation, only the main differences to the embodiment shown in fig. 2 will be described. Further, some features shown in fig. 2, such as the control unit, are not shown in fig. 37, although they form parts of the embodiment described with reference to fig. 37.

The internal combustion engine system 30 in fig. 37 comprises a plurality of inductively heatable elements 218, 918 arranged after each other along the longitudinal direction of the exhaust gas passage 10. According to this example, each one of the inductively heatable elements has mixing properties. In other words, the magnetic properties and mixing properties are achieved in a one-piece unit. Further, the plurality of inductively heatable elements 218,918 are arranged with such distance in the longitudinal direction of the exhaust gas passage 10 in relation to the extension of a single heater 20 in the longitudinal direction of the exhaust gas passage 10 that the heater covers both mixers 218,918.

The exhaust gas treatment system 32 in fig. 37 is of a linear design, wherein the components are arranged after each other along a substantially linear extension of the exhaust gas passage.

Fig. 38 is a schematic view of an exhaust gas treatment system according to an alternative to the system in fig. 37. In this embodiment, the selective catalytic reduction catalyst 12' is coated on the particulate filter 36'. In other words, the position of the particulate filter 36' has been changed in relation to fig. 37 and is now integrated with the SCR 12' in a position downstream of the urea injection device 14.

Fig. 39 shows another embodiment of an internal combustion engine system 50 comprising the internal combustion engine 6 and an exhaust gas treatment system 52. For ease of presentation, only the main differences to the embodiment shown in fig. 37 will be described. In contrast to the embodiment shown in fig. 37, the exhaust gas passage comprises three substantially linear sections arranged in parallel with each other and with turning sections interconnecting the linear sections. More specifically, a first end 54 of a first linear exhaust passage section 56 is connected to the engine 6 and a second end 58 of the first linear exhaust passage section 56 is connected to a first turning section 60. Further, a first end 62 of a second linear exhaust passage section 64 is connected to the first turning section 60 and a second end 66 of the second linear exhaust passage section 64 is connected to a second turning section 68. Further, a first end 70 of a third linear exhaust passage section 72 is connected to the second turning section 68 and a second end 74 of the third linear exhaust passage section 72 is connected to atmosphere. Thus, the exhaust gas flows in opposite directions in the first and second linear sections 56, 64 and in opposite directions in the second and third linear sections 64, 72.

The DOC 34 and the DPF 36 are positioned in the first linear section 56. The reductant injector 14 is positioned in the first turning section 60. A first inductively heatable element 218 is positioned in the second linear section 64. Further, a first heater 20a associated to the first inductively heatable element 218 is positioned along the second linear section 64. A second inductively heatable element 918 is positioned in the third linear section 72. Further, a second heater 20b associated to the second mixer 918 is positioned along the third linear section 72. Further, the SCR catalyst 12 is positioned downstream of the second inductively heatable element 918 in the third linear section 72.

The system 50 comprises a box 76 surrounding the exhaust gas passage 10 comprising the first, second and third linear sections 56, 64, 72 and the interconnecting turning sections 60, 68.

Fig. 40 shows a third embodiment of an internal combustion engine system 80 comprising the internal combustion engine and an exhaust gas treatment system 82. For ease of presentation, only the main differences to the embodiment shown in fig. 39 will be described. The system 80 comprises a box 84 with an inner shell 86 surrounding a portion of the second linear section 66 comprising the first mixer 218 and associated first heater 20a. The inner shell 86 is adapted to be with drawable from the box 84 for service or exchange of parts.

Further, the exhaust passage 10 comprises an opening structure 88 downstream of the SCR catalyst 12 and inside of the box 84 so that the treated exhaust gas may circulate inside the box 84 before reaching the atmosphere. This may serve for heat distribution and noise reduction.

It is to be understood that the present invention is not limited to the embodiments described above and illustrated in the drawings; rather, the skilled person will recognize that many changes and modifications may be made within the scope of the appended claims. For example, the system may comprise any combination of the above-mentioned embodiments of the inductively heatable elements. Further, it may be noted that the contents of different claims may be combined to embodiments not explicitly shown in the description above.

According to one alternative, the inductively heatable element may form a grid or lattice structure. Further, the grid structure extends over the complete inner cross section of the exhaust passage wall 101. Further, the ends of the cross bars forming the grid structure are rigidly connected to the exhaust passage wall 101.

According to one alternative, or complement, the system comprises an energy storage arrangement, such as one or a plurality of batteries, which is adapted to be charged from an electrical grid/network, is arranged for providing power to the heater.

CLAIMS

1. A method for controlling an exhaust gas treatment system (8) arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit (10), and a selective catalytic reduction catalyst (12) provided in the exhaust conduit (10), characterized by providing (S4, S102, S203) an alternating current through an electric conduit (20) located externally of the exhaust conduit (10), thereby providing induction heating of a portion (101, 118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) of the exhaust conduit located upstream of the catalyst (12), and supplying (S5, S107), into the exhaust conduit (10), a reductant for an exhaust gas treatment process in the catalyst (12).

2. A method according to claim 1, characterized in the reductant is supplied (S5, S107) upstream of said portion (101, 118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) of the exhaust conduit.

3. A method according to any one of the preceding claims, characterized in that said portion of the exhaust conduit is a portion of a delimiting wall (101) of the exhaust conduit (10) and/or an element (118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) located inside a delimiting wall (101) of the exhaust conduit (10).

4. A method according to claim 3, characterized by allowing the element (118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) to alter a flow of exhaust gases in the exhaust conduit (10).

5. A method according to any one of the preceding claims, characterized by determining (S1) a rate of reductant consumption by the exhaust gas treatment process in the catalyst (12), wherein the supply (S5) of the reductant is controlled so as to provide a flow of reductant that is higher than the determined rate of reductant consumption.

6. A method according to claim 5, characterized by terminating (S8) the supply of the reductant.

7. A method according to claims 5 and 6, characterized by repeating the steps of supplying (S5) a reductant so as to provide a flow of reductant that is higher than the determined rate of reductant consumption, and terminating (S8) the supply of the reductant.

8. A method according to any one of the preceding claims, characterized by starting (S101) the engine, and initiating (S102) the provision of the alternating current through the electric conduit (20) simultaneously or at a predetermined point in time before or after the engine start (S101).

9. A method according to any one of the preceding claims, characterized by determining (S103) the effect on the temperature in the exhaust conduit (10) provided by the induction heating, and controlling (S107) the supply of the reductant in dependence on the determined temperature effect.

10. A method according to claim 9, characterized in that determining the temperature effect comprises determining (S103) the temperature in the exhaust conduit (10) downstream of said portion (101, 118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) of the exhaust conduit.

11. A method according to claim 10, characterized by initiating the supply (S107) of reductant in dependence (S104) on whether the determined temperature in the exhaust conduit (10) is above a predetermined temperature threshold value.

12. A method according to any one of the preceding claims, characterized by determining (S105) an amount of stored reductant in the catalyst (12).

13. A method according to claim 12, characterized by controlling the supply (S107) of the reductant in dependence on the determined (S105) stored reductant amount.

14. A method according to claim 13, characterized by initiating the supply (S107) of reductant in dependence (S106) on whether the determined stored reductant amount is below a predetermined reductant amount threshold value.

15. A method according to any one of claims 12-14, characterized by initiating the provision of the alternating current through the electric conduit (20) in dependence on the determined stored reductant amount.

16. A method according to claim 15, characterized by initiating the provision of the alternating current in dependence on whether the determined stored reductant amount is below a predetermined reductant amount threshold value.

17. A method according to any one of the preceding claims, characterized by supplying (S204) compressed air into the exhaust conduit (10) upstream of the supply of the reductant into the exhaust conduit (10).

18. A method according to claim 17, characterized by determining (S201) a need to start the engine, and initiating the supply (S204) of compressed air and the provision (S203) of the alternating current through the electric conduit (20) in dependence (S201) on the determined engine start need.

19. A method for controlling an exhaust gas treatment system (8) arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit (10), characterized by supplying (S204) compressed air into the exhaust conduit (10).

20. A method according to claim 19, where the exhaust gas treatment system comprises a catalyst (12) provided in the exhaust conduit (10), characterized by heating (S203) an exhaust gas in the exhaust conduit (10) upstream of the catalyst (12) and downstream of the compressed air supply into the exhaust conduit (10).

21. A method according to claim 20, characterized in that heating the exhaust gas comprises providing (S203) an alternating current through an electric conduit (20) located externally of the exhaust conduit (10), thereby providing induction heating of an portion (101, 118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) of the exhaust conduit located upstream of the catalyst (12) and downstream of the compressed air supply into the exhaust conduit (10).

22. A method according to any one of claims 20-21, where the catalyst (12) is a selective catalytic reduction catalyst (12), characterized by supplying, into the exhaust conduit (10) upstream of the heating (S203) of the exhaust gas and downstream of the compressed air supply into the exhaust conduit (10), a reductant for an exhaust gas treatment process in the catalyst (12).

23. A computer program comprising program code means for performing the steps of any one of the preceding claims when said program is run on a computer.

24. A computer readable medium carrying a computer program comprising program code means for performing the steps of any one of claims 1-22 when said program product is run on a computer.

25. A control unit configured to perform the steps of the method according to any one of claims 1-22.

26. An exhaust gas treatment system (8) comprising an exhaust conduit (10), characterized in that the exhaust gas treatment system comprises an air compressor (400), the exhaust gas treatment system being arranged to supply air from the air compressor (400) into the exhaust conduit (10).

27. An exhaust gas treatment system (8) according to claim 26, characterized in that the exhaust gas treatment system comprises a catalyst (12) provided in the exhaust conduit (10), downstream of the supply of air into the exhaust conduit (10).

28. An exhaust gas treatment system (8) according to claim 27, characterized in that the exhaust gas treatment system comprises an arrangement (16) for heating an exhaust gas in the exhaust conduit (10) and/or a portion (101, 118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) of the system, upstream of the catalyst (12) and downstream of the supply of air into the exhaust conduit (10).

29. An exhaust gas treatment system according to claim 28, characterized in that the heating arrangement (16) is adapted for inductive heating and that it comprises a heater (20, 20a) positioned externally of the exhaust conduit (10).

30. An exhaust gas treatment system (8) according to any one of claims 27-29, characterized in that the catalyst (12) is a selective catalytic reduction catalyst (12), and the exhaust gas treatment system comprises a means (14) for supplying a reductant into the exhaust conduit (10) upstream of the catalyst (12) and downstream of the supply of air into the exhaust conduit (10).

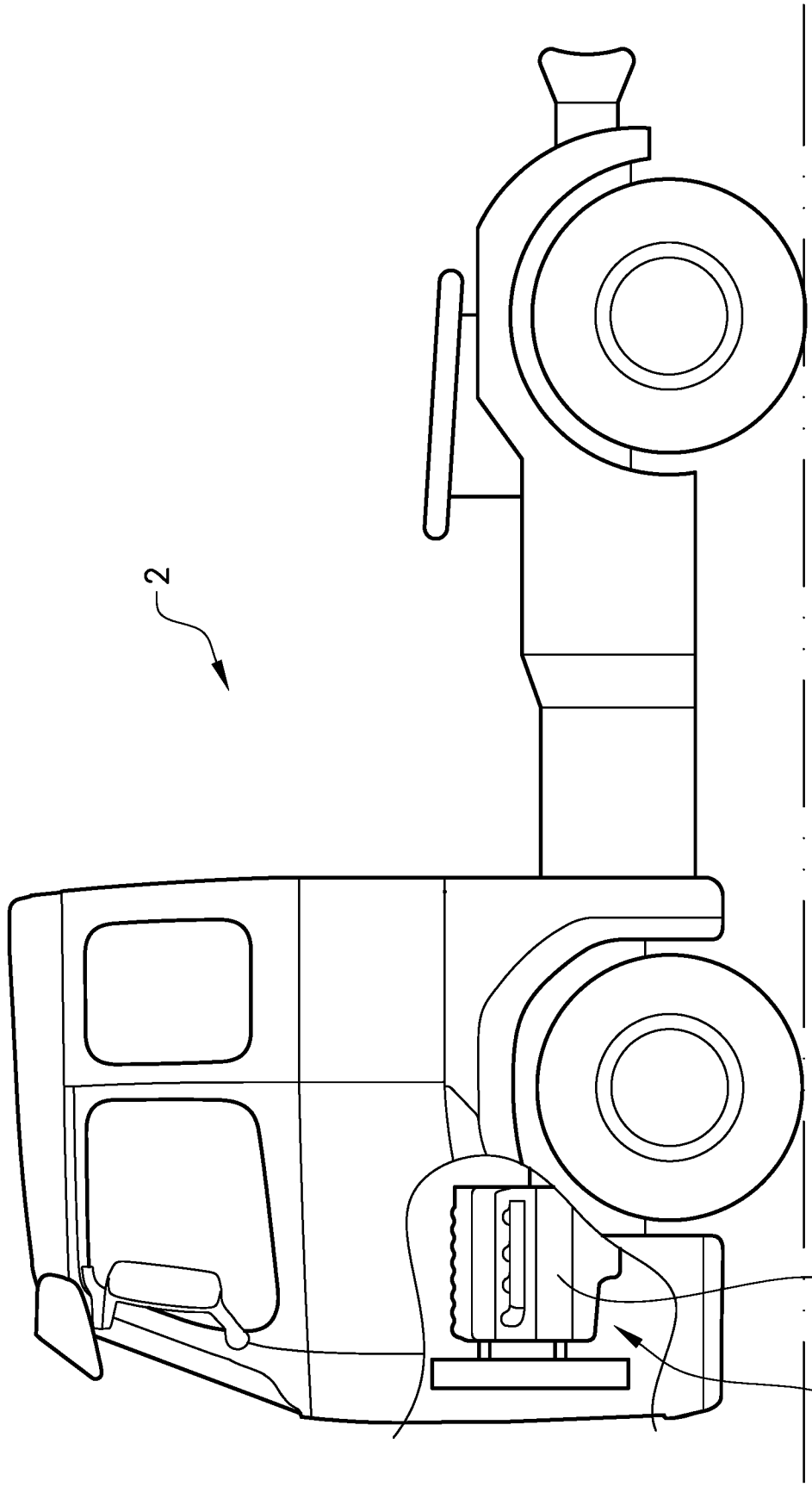


FIG. 1

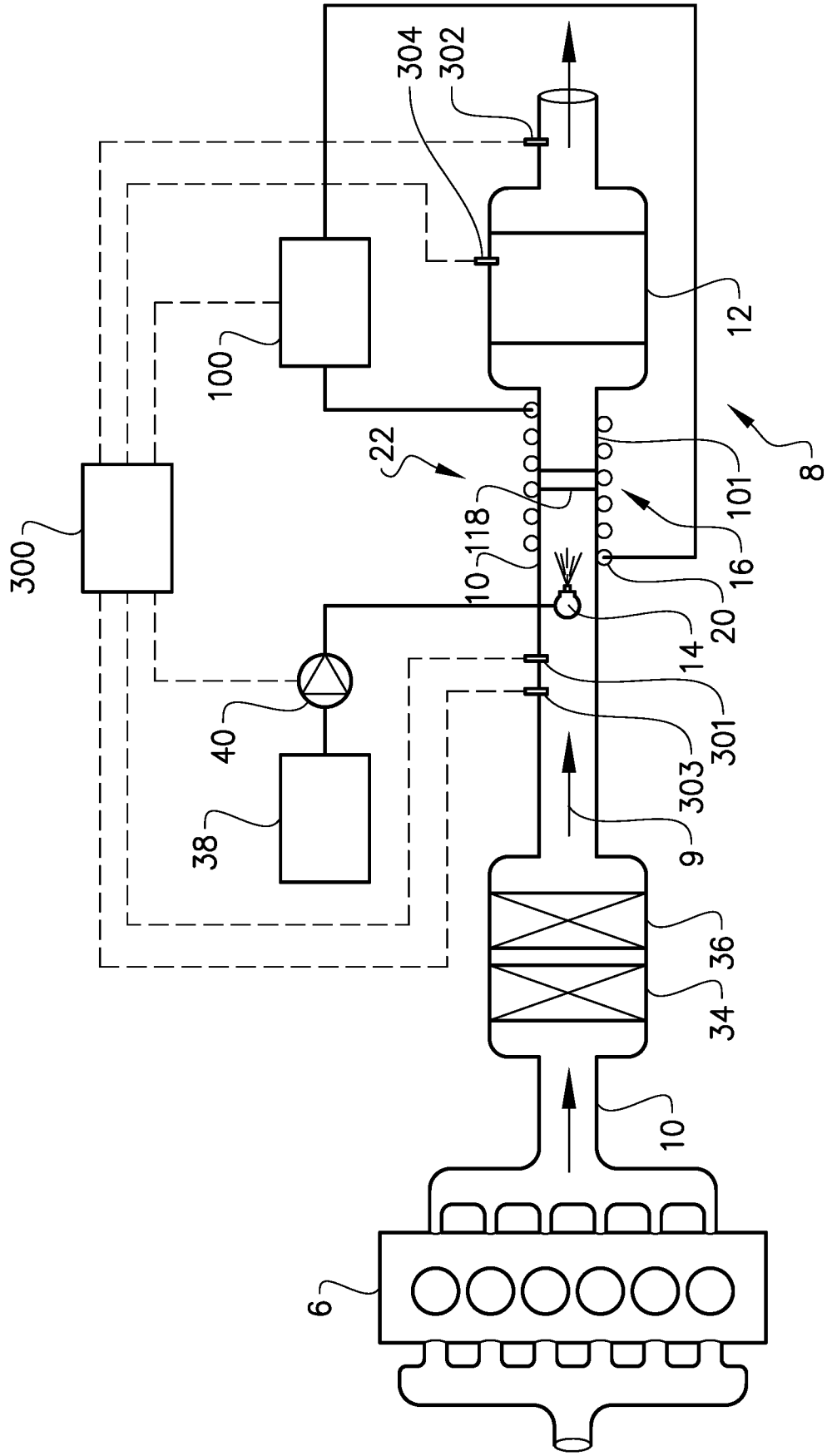


FIG. 2

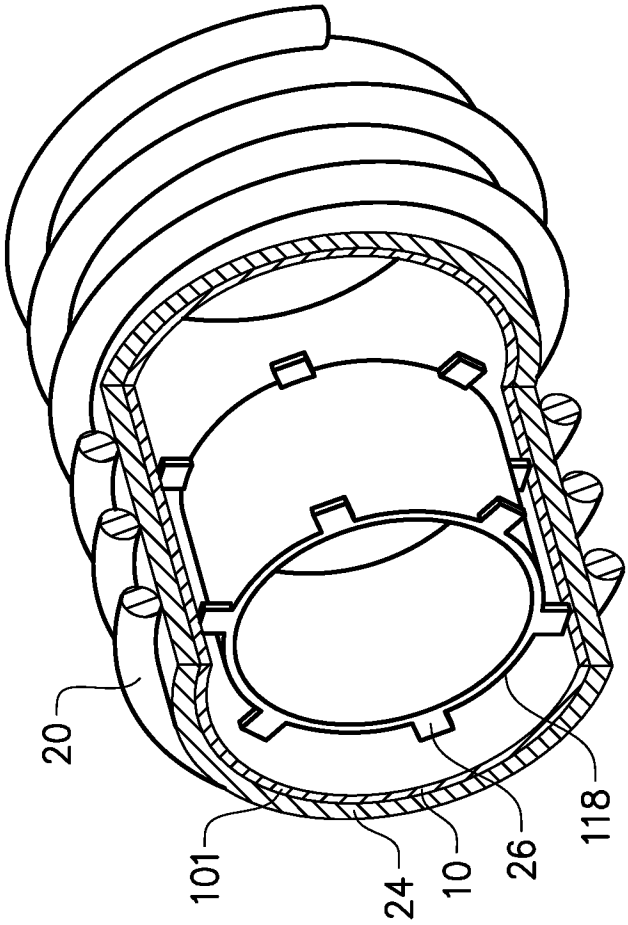


FIG. 4

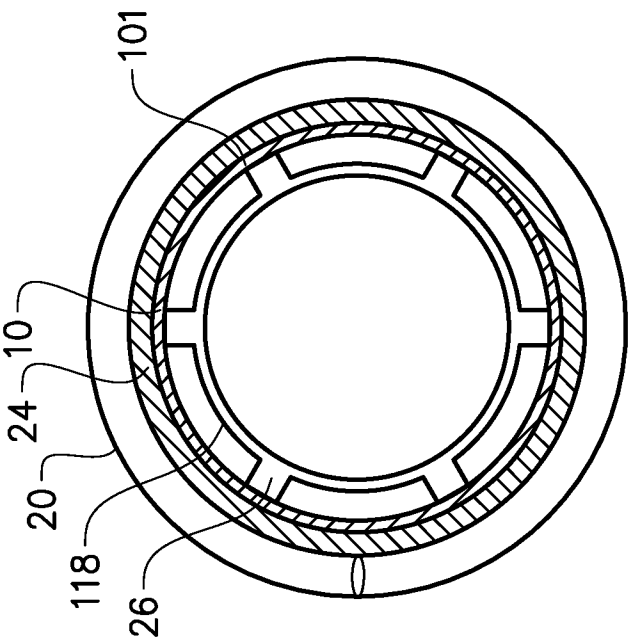


FIG. 3

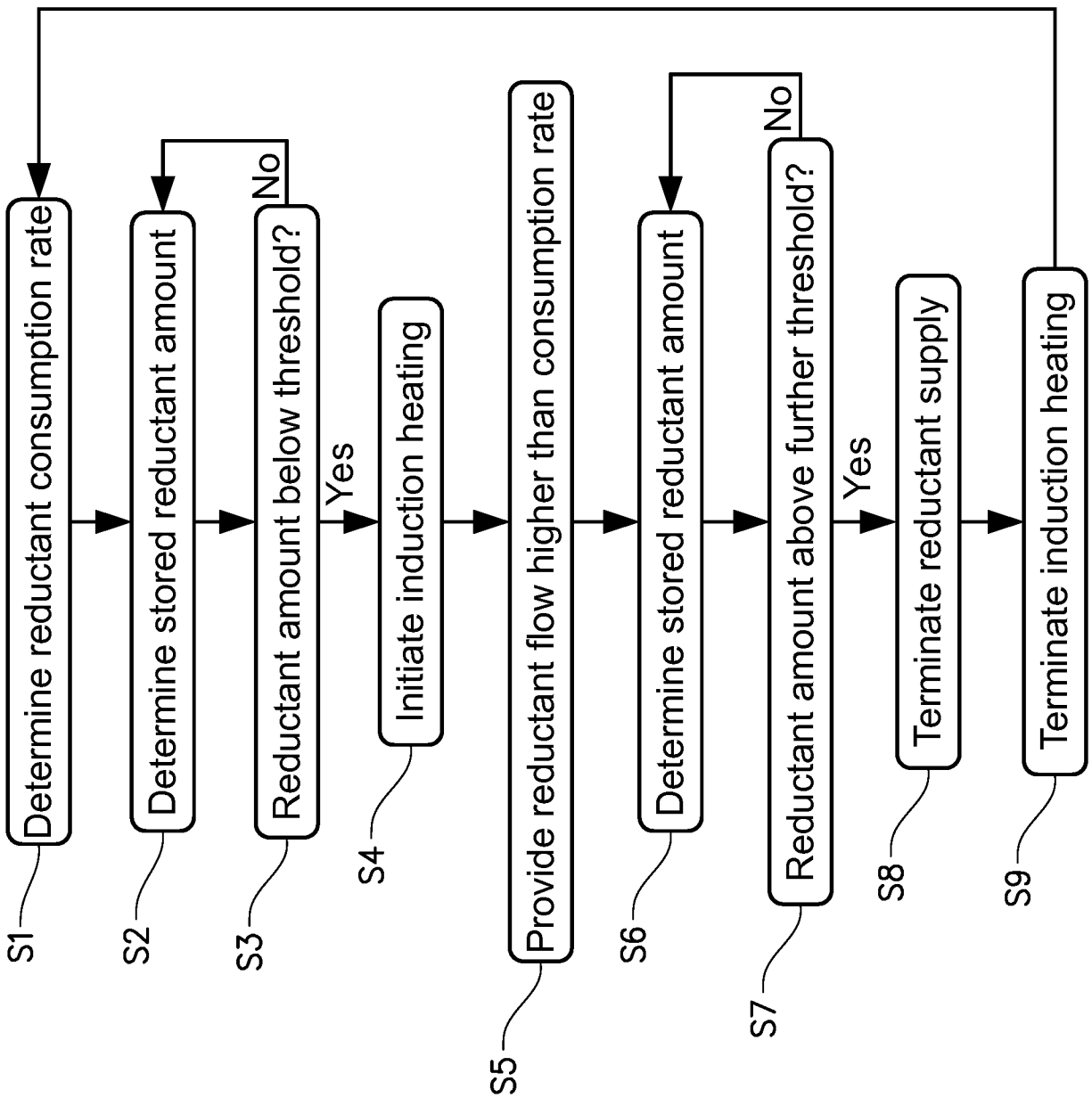

Determine reductant consumption rate
S1
Determine stored reductant amount
S2
Reductant amount below threshold?
No
Yes
S3
Initiate induction heating
S4
Provide reductant flow higher than consumption rate
S5
Determine stored reductant amount
S6
Reductant amount above further threshold?
No
Yes
S7
Terminate reductant supply
S8
Terminate induction heating
S9

FIG. 5

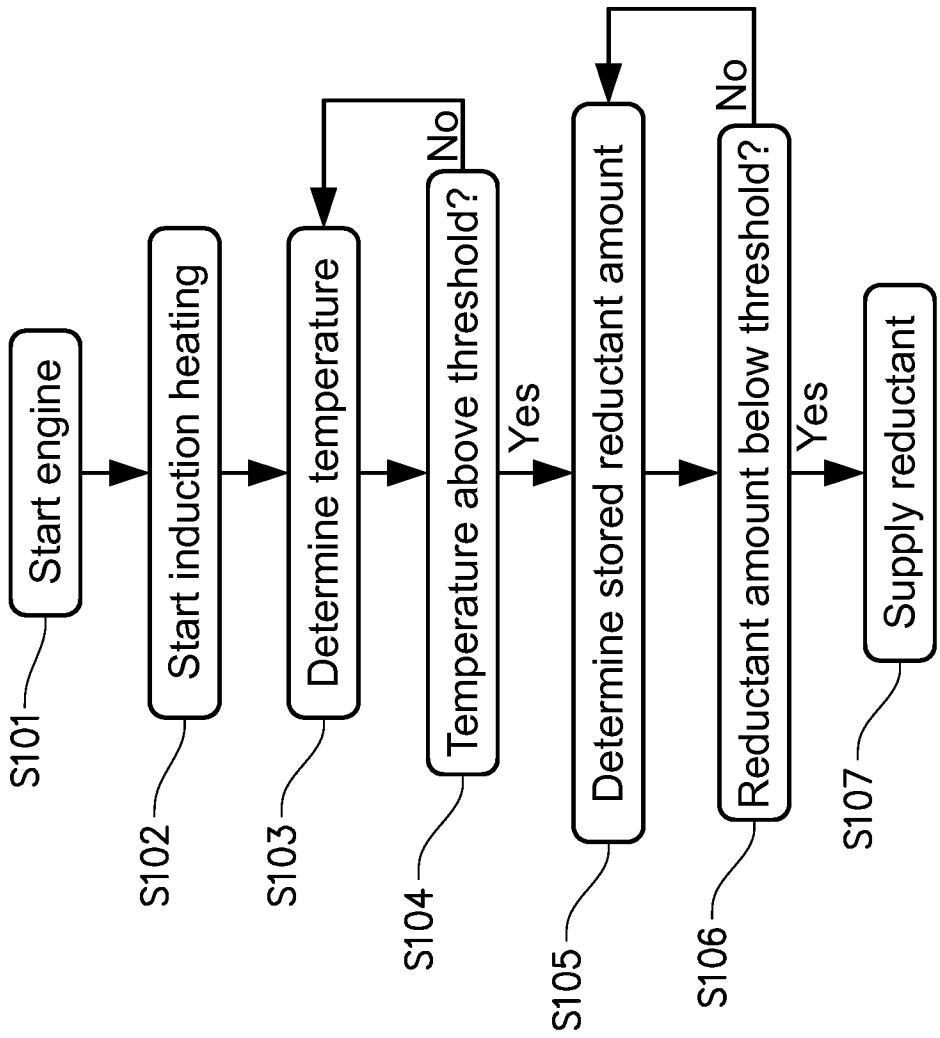

Start engine
S101
Start induction heating
S102
Determine temperature
S103
Temperature above threshold?
S104
No
Yes
Determine stored reductant amount
S105
Reductant amount below threshold?
S106
No
Yes
Supply reductant
S107

FIG. 6

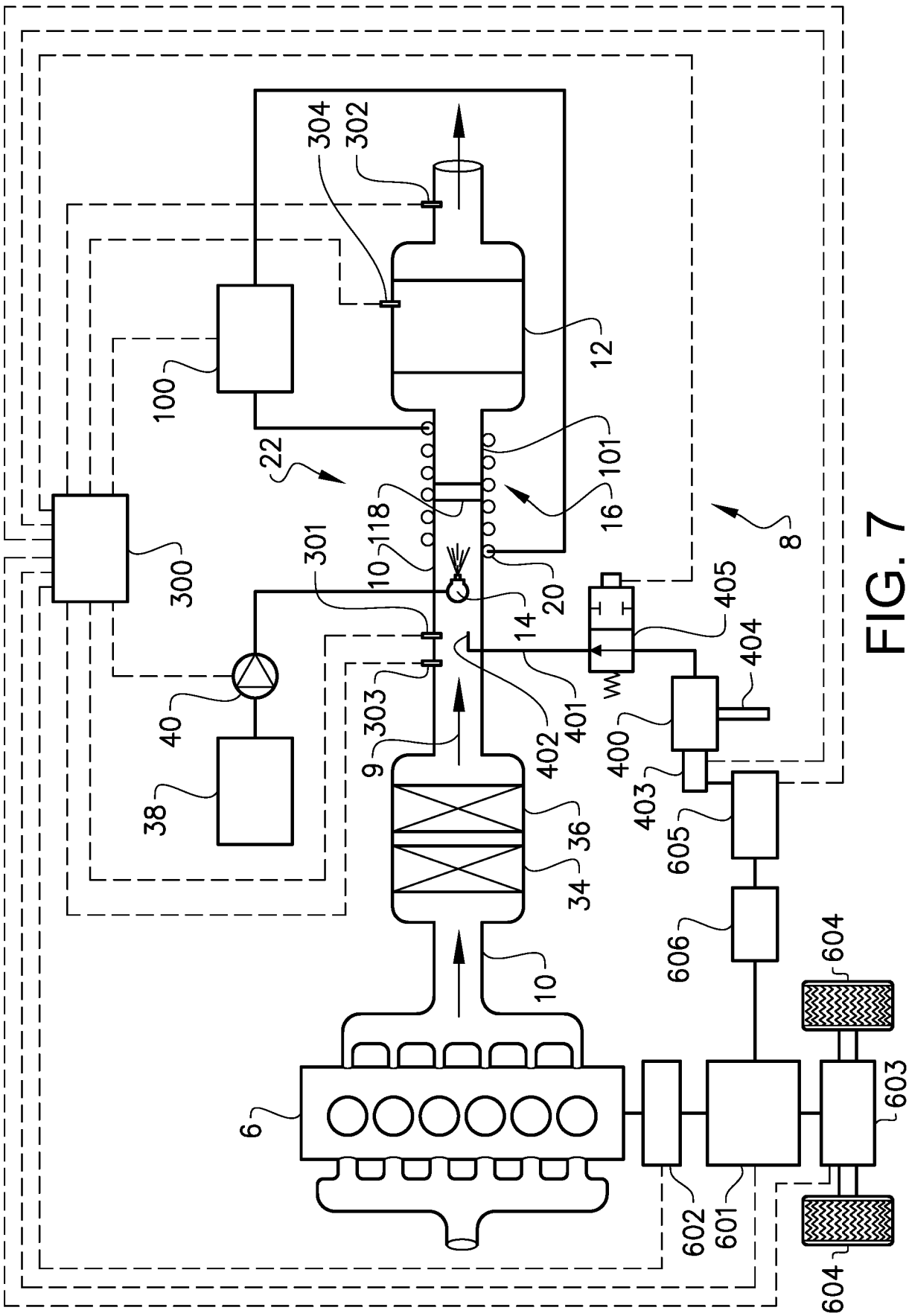

304
302
12
100
22
101
16
8
118
10
300
301
20
405
14
404
40
303
9
402
401
400
403
605
38
36
34
606
604
10
6
603
602
601
604

FIG. 7

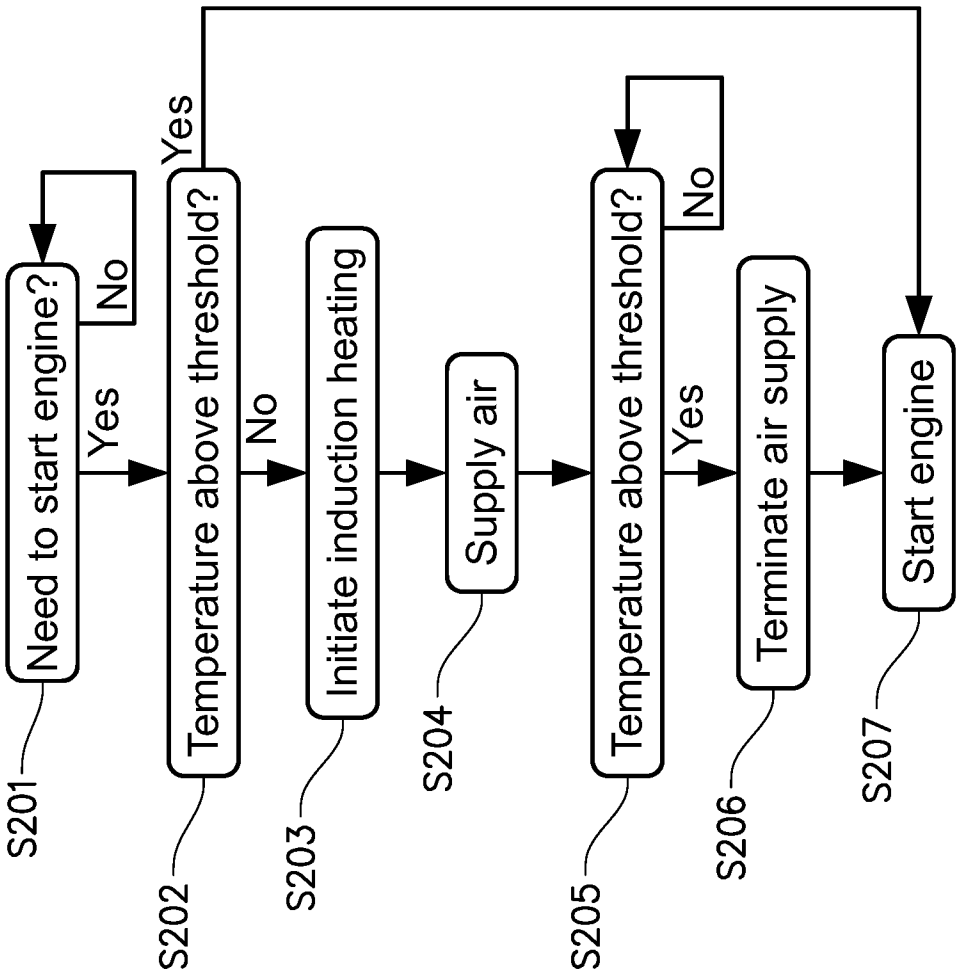

Need to start engine?
No
Yes
S201
Temperature above threshold?
Yes
No
S202
Initiate induction heating
S203
Supply air
S204
Temperature above threshold?
No
Yes
S205
Terminate air supply
S206
Start engine
S207

FIG. 8

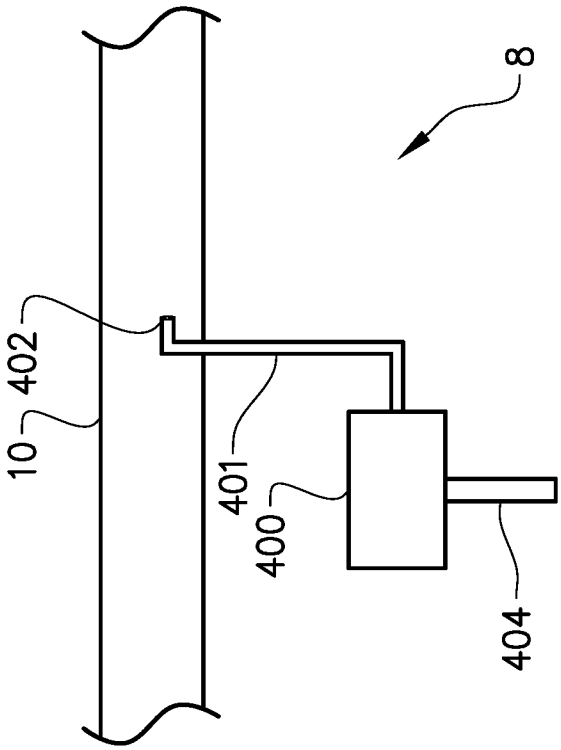


FIG. 9

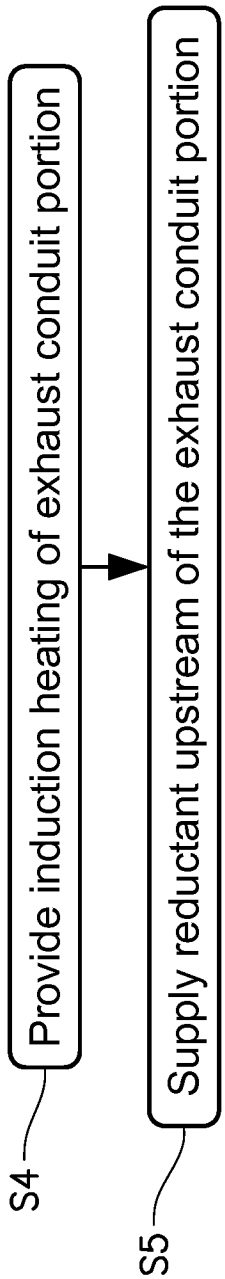

Provide induction heating of exhaust conduit portion
Supply reductant upstream of the exhaust conduit portion
S4
S5

FIG. 10

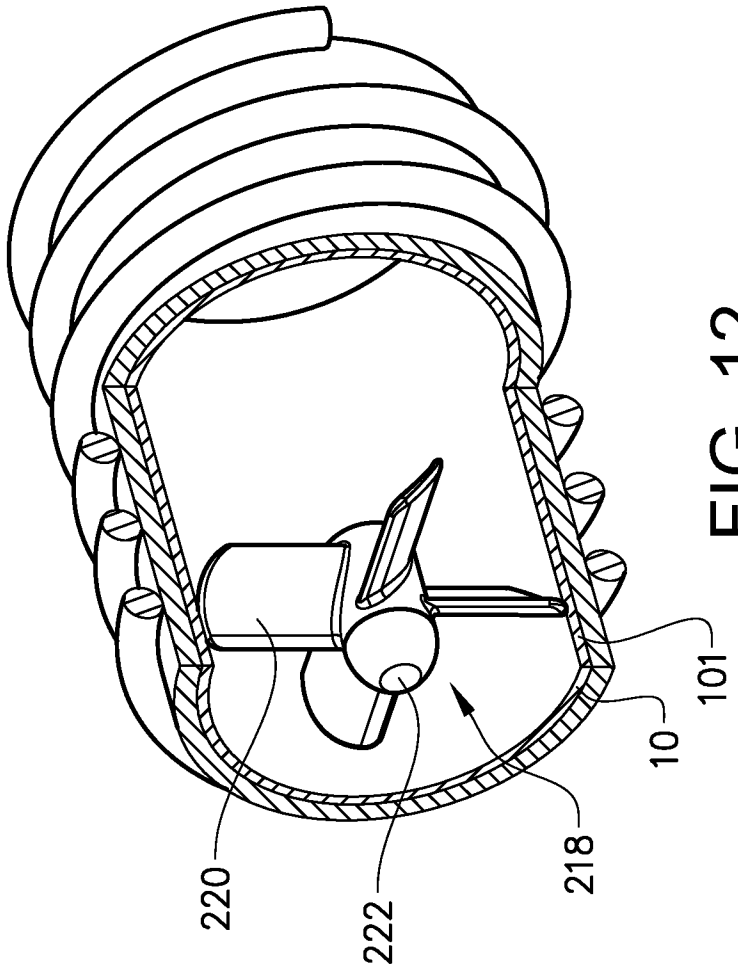


FIG. 12

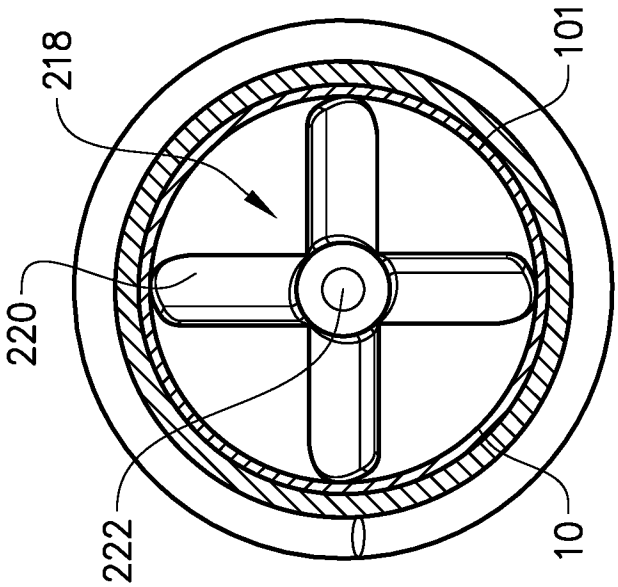


FIG. 11

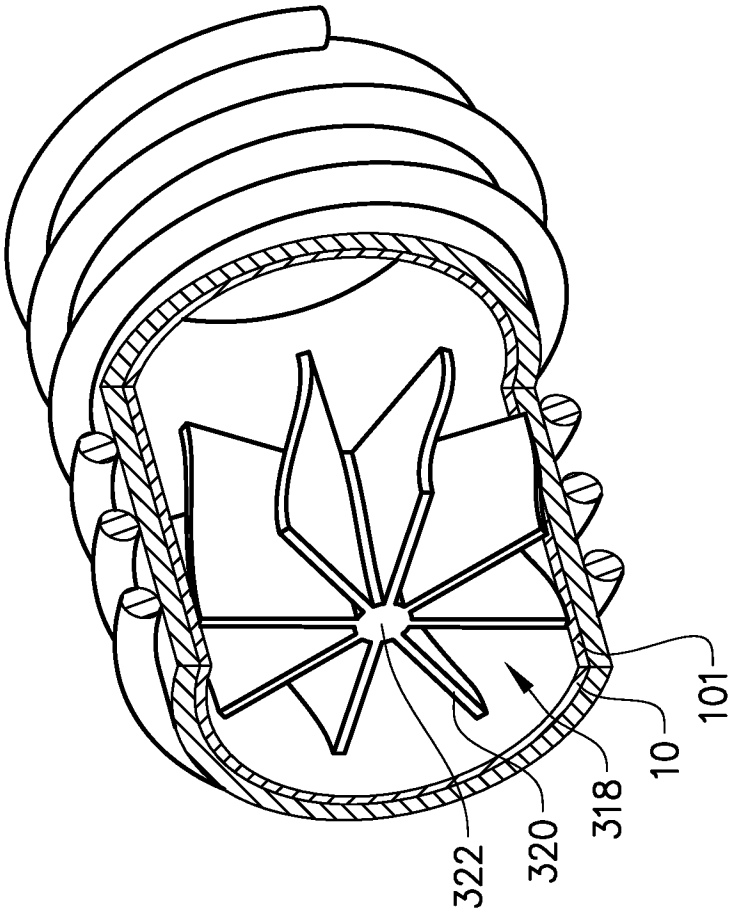


FIG. 14

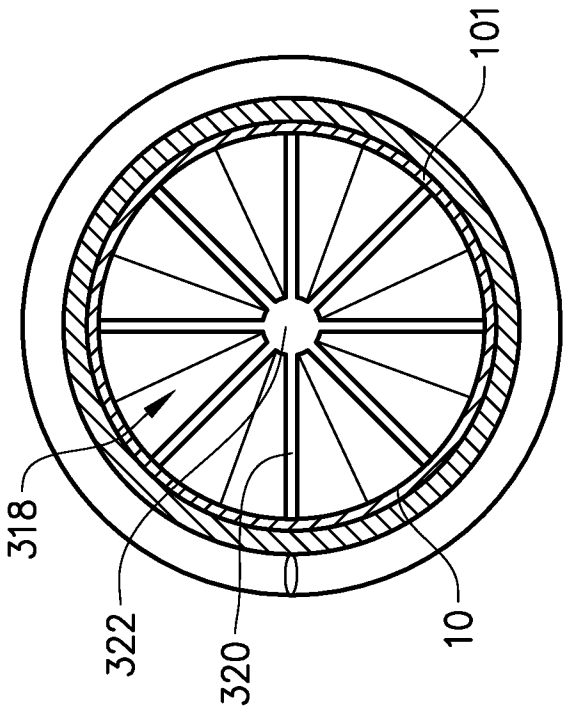


FIG. 13

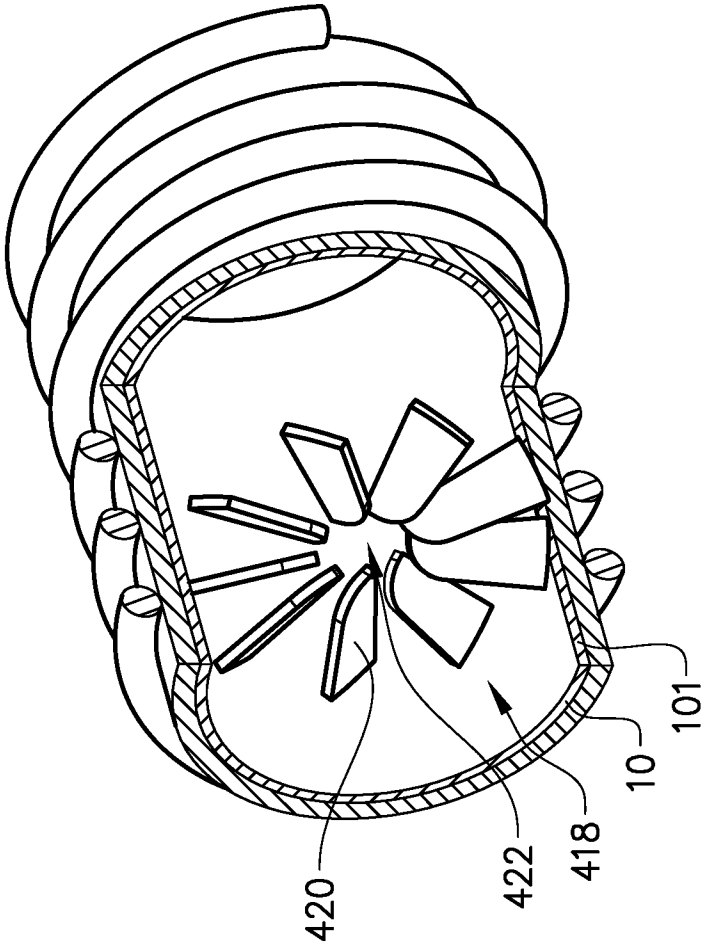


FIG. 16

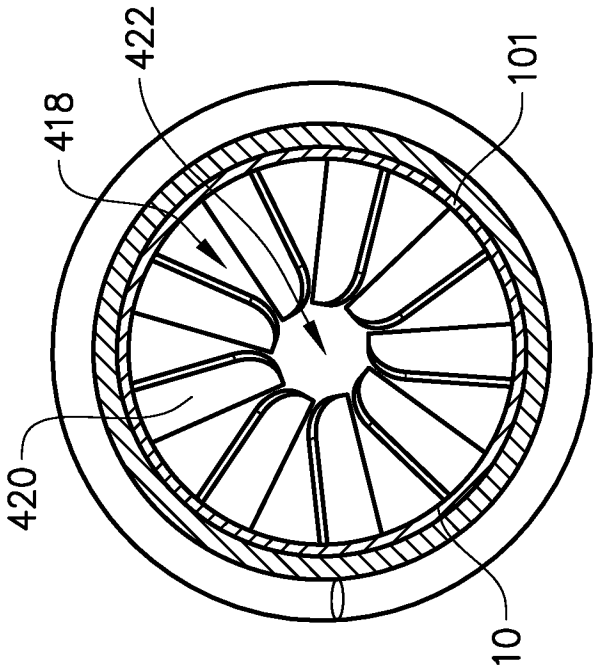


FIG. 15

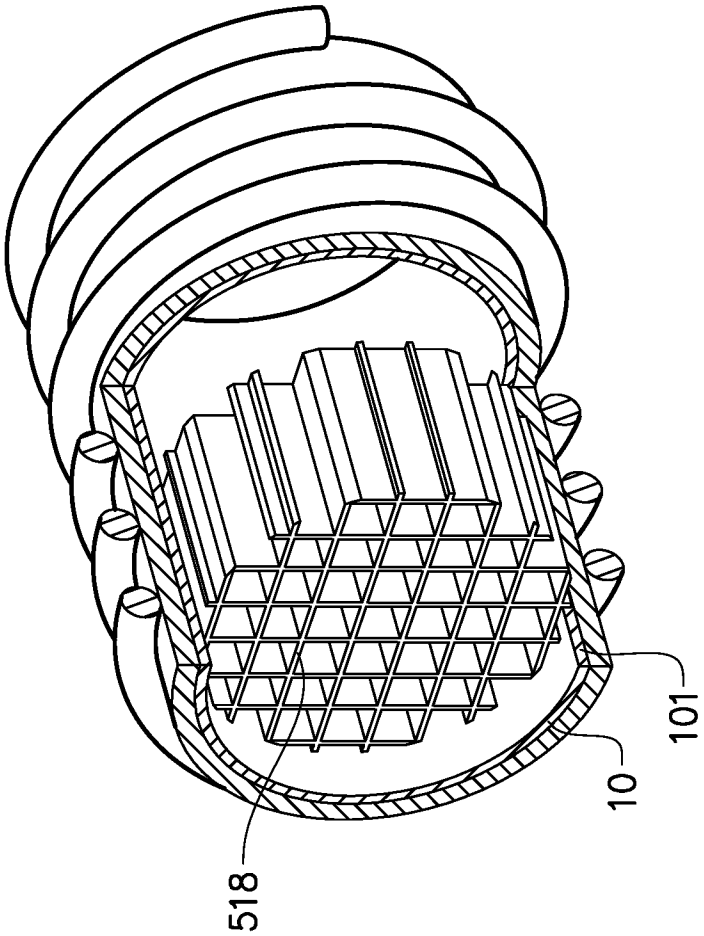


FIG. 18

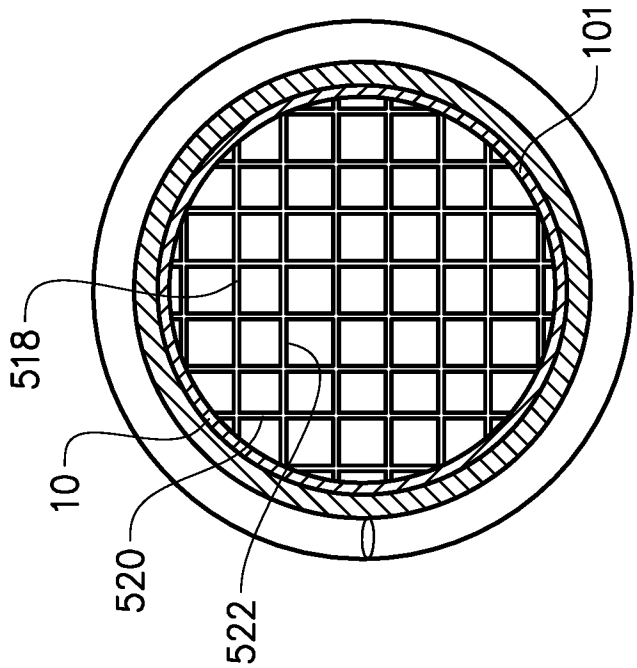


FIG. 17

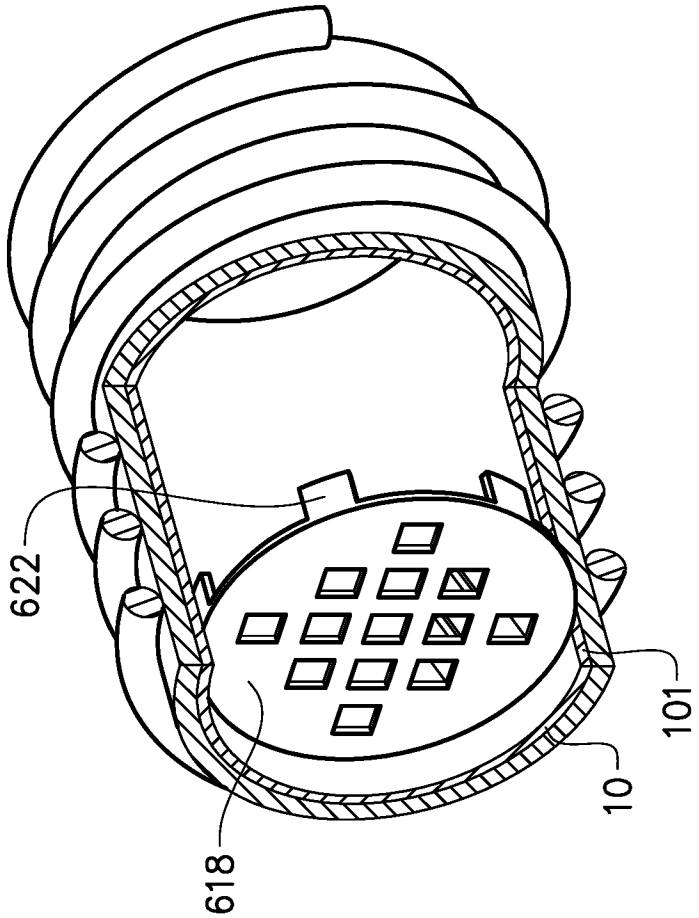


FIG. 20

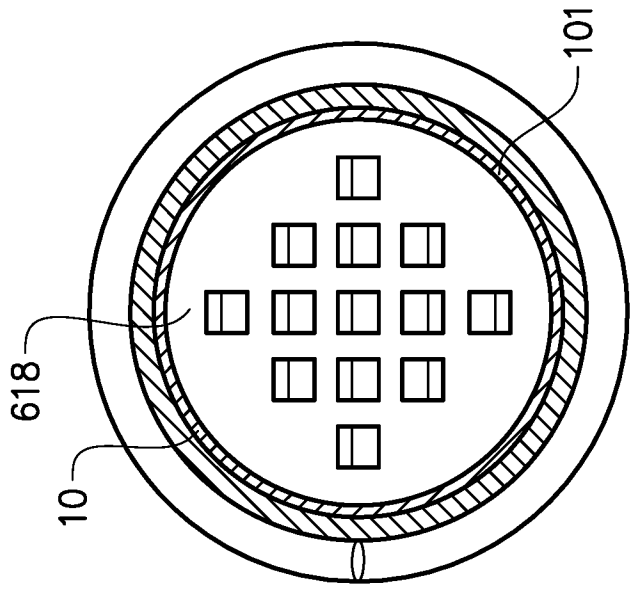


FIG. 19

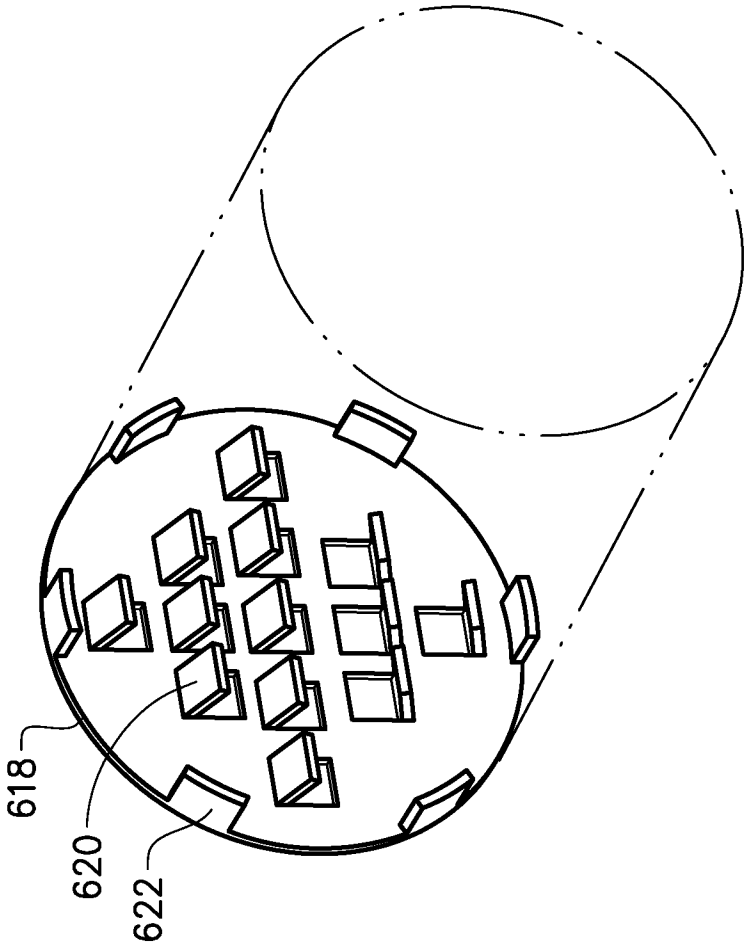


FIG. 21

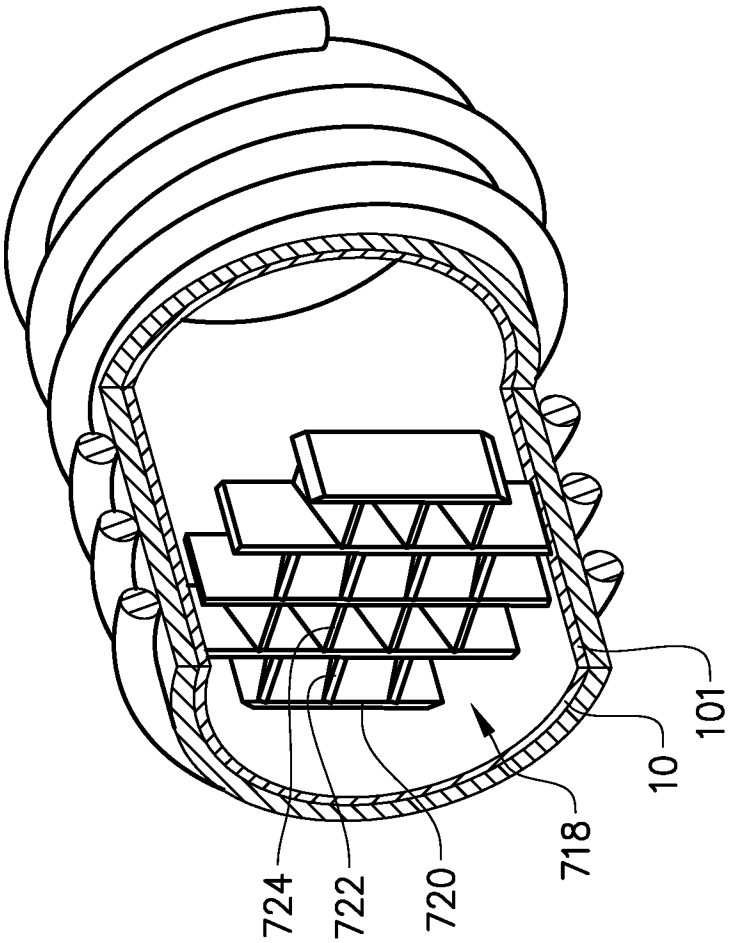


FIG. 23

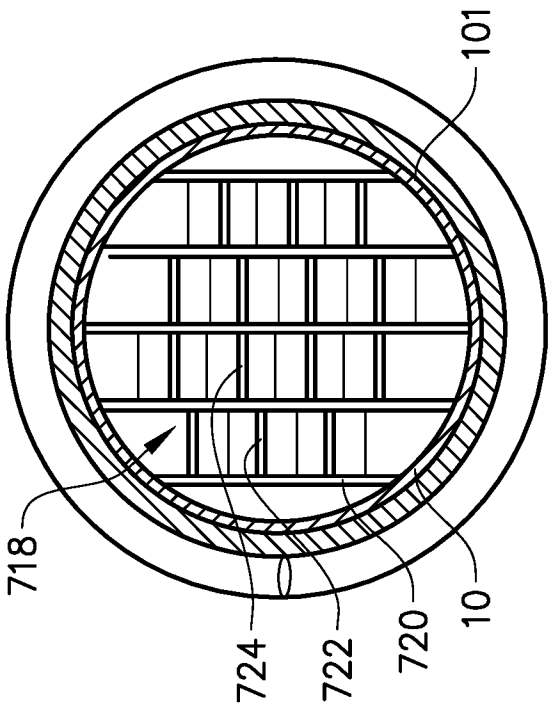


FIG. 22

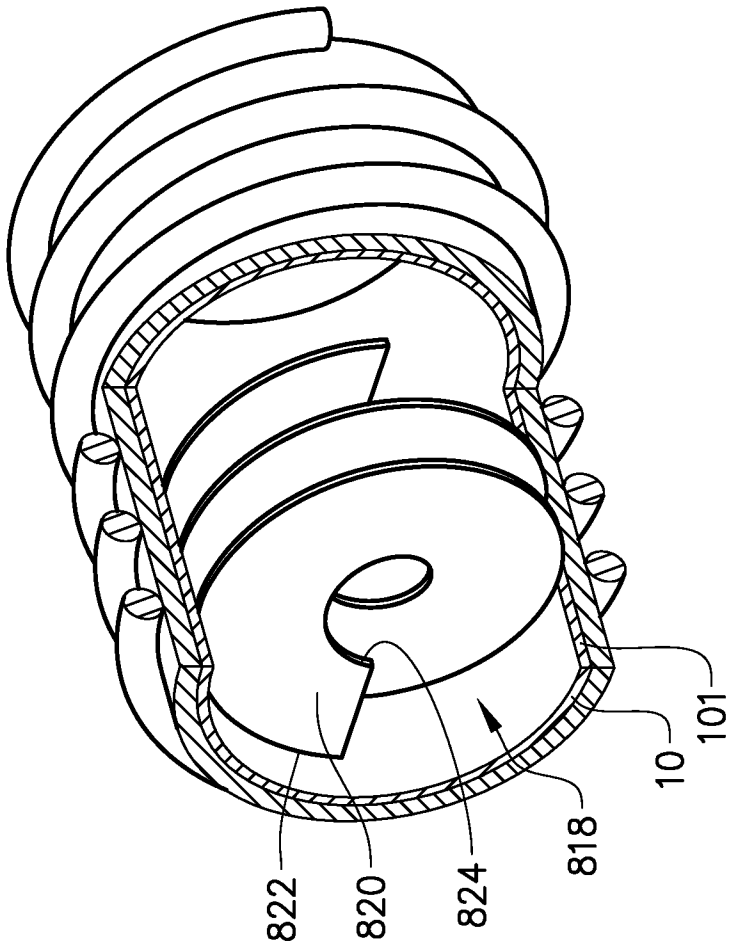


FIG. 25

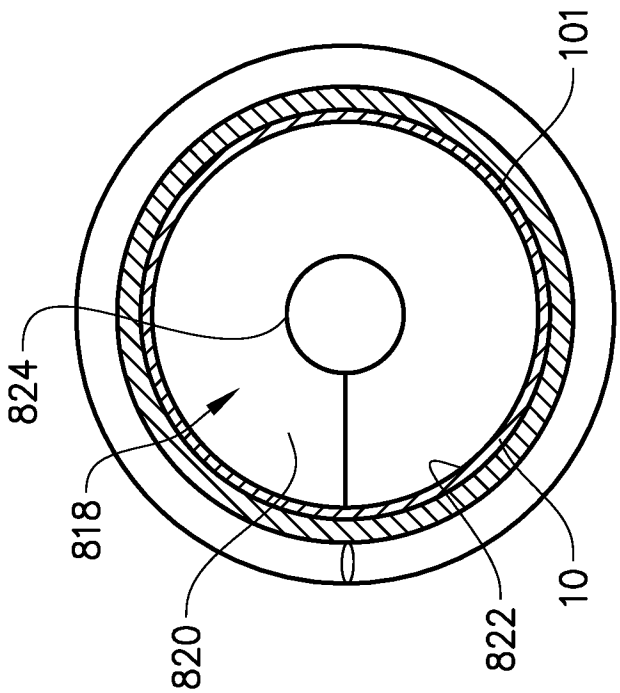


FIG. 24

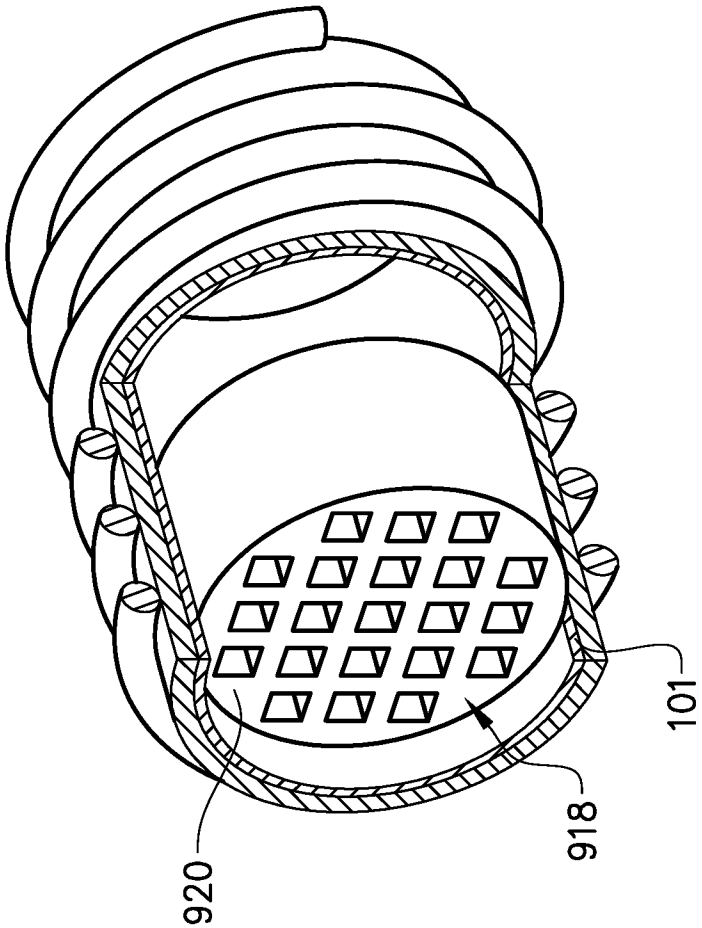


FIG. 27

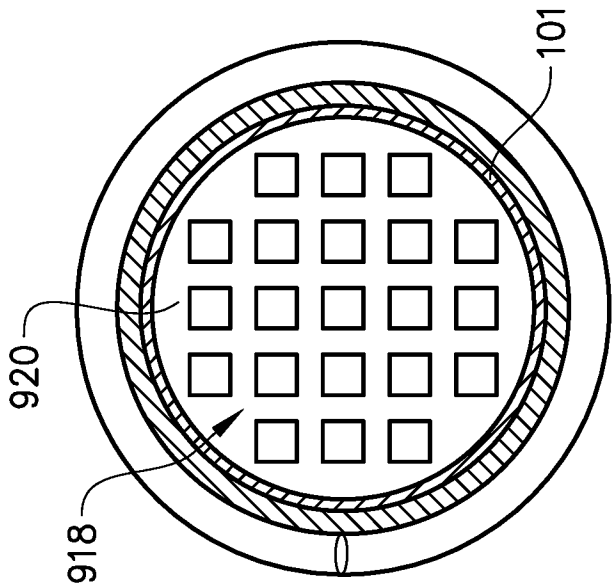


FIG. 26

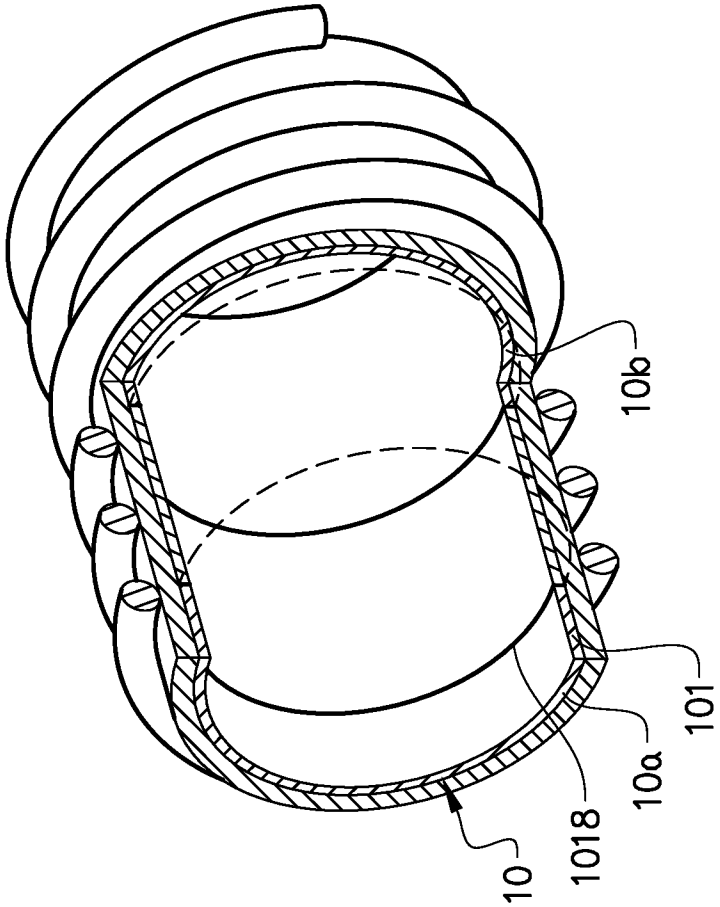


FIG. 28

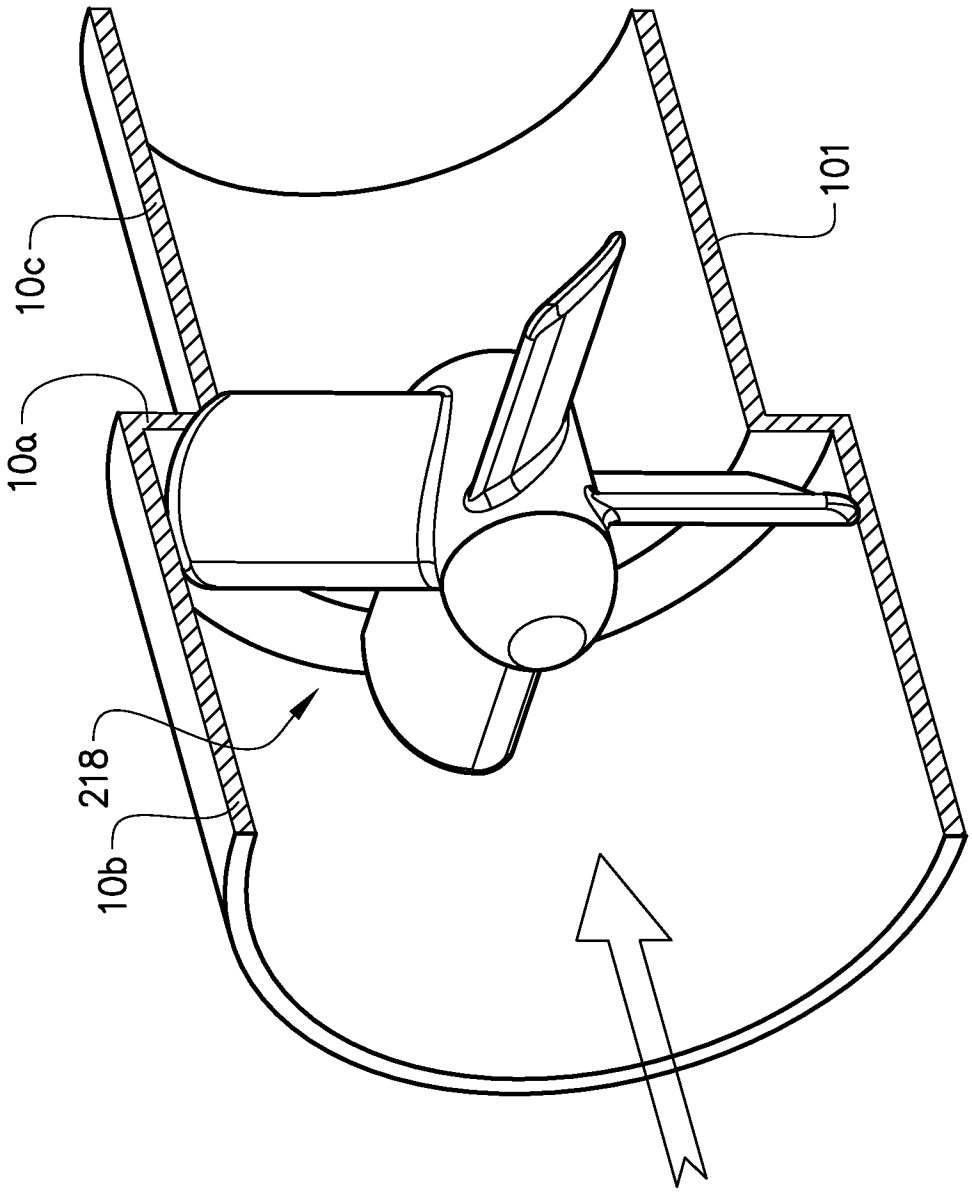


FIG. 29

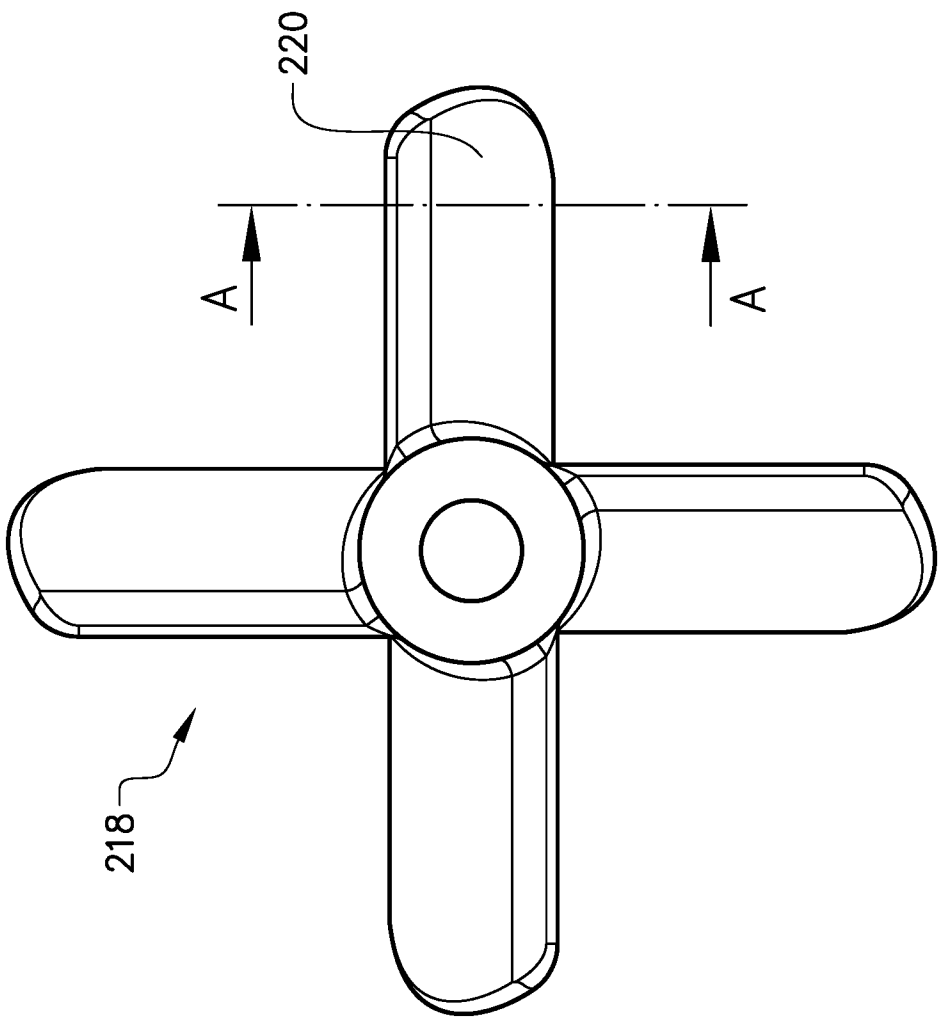


FIG. 30

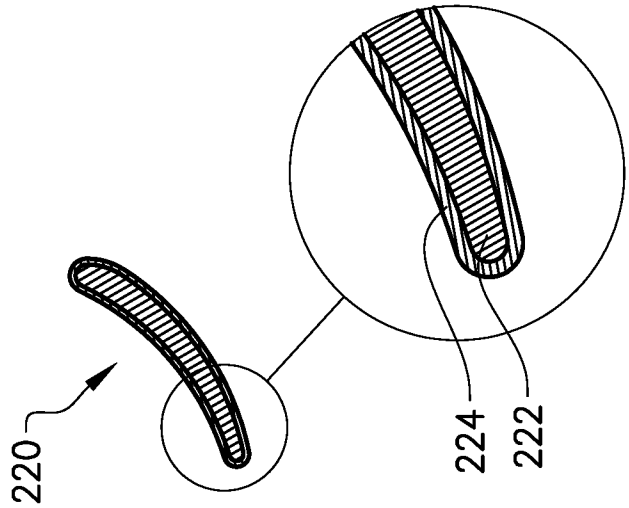


FIG. 31 A-A

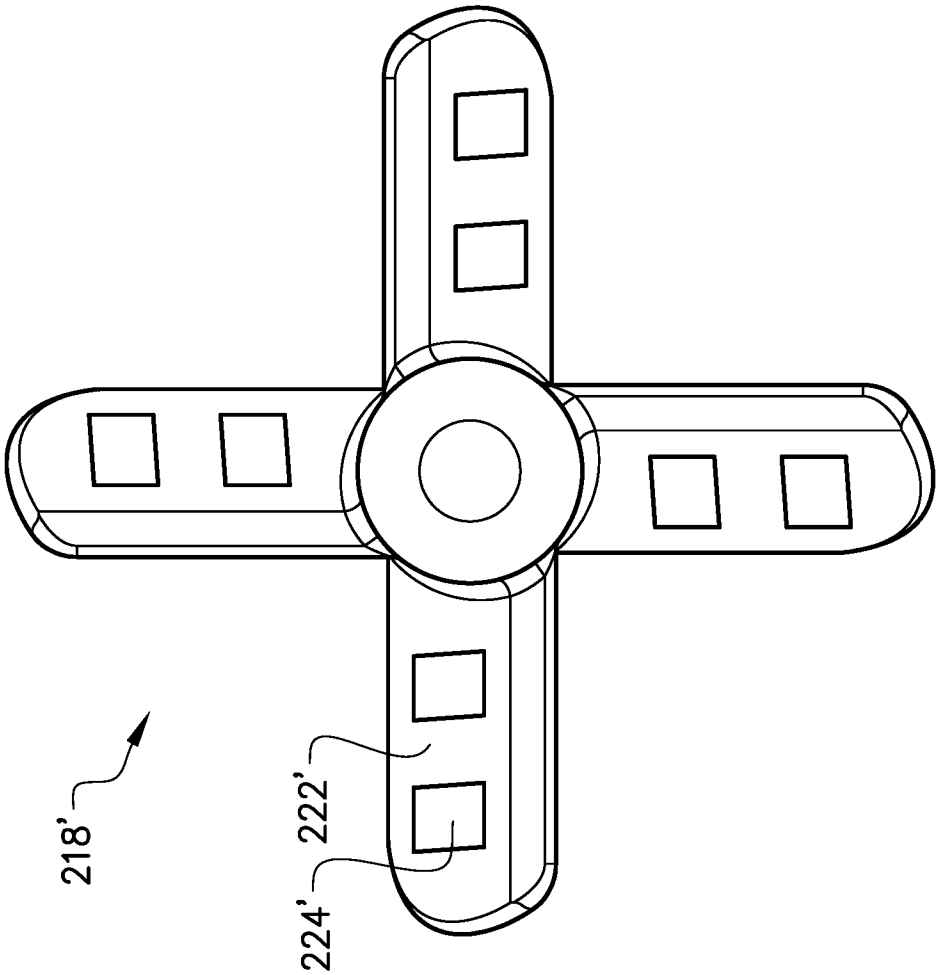


FIG. 32

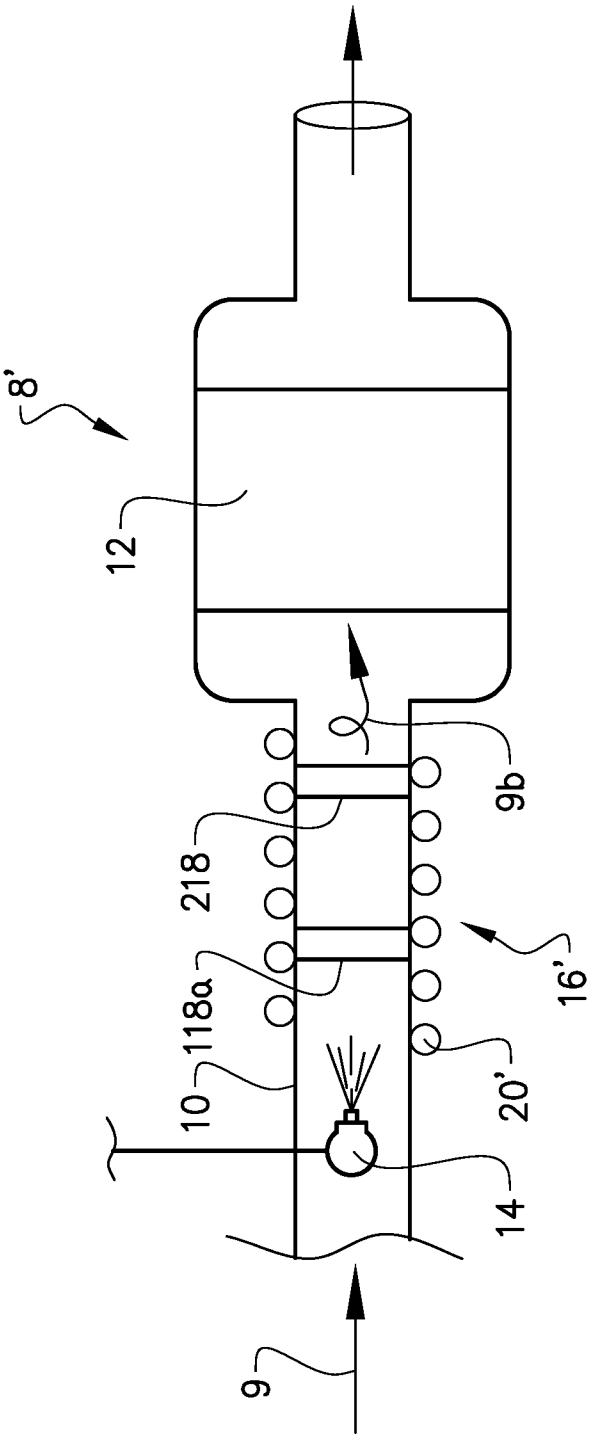


FIG. 33

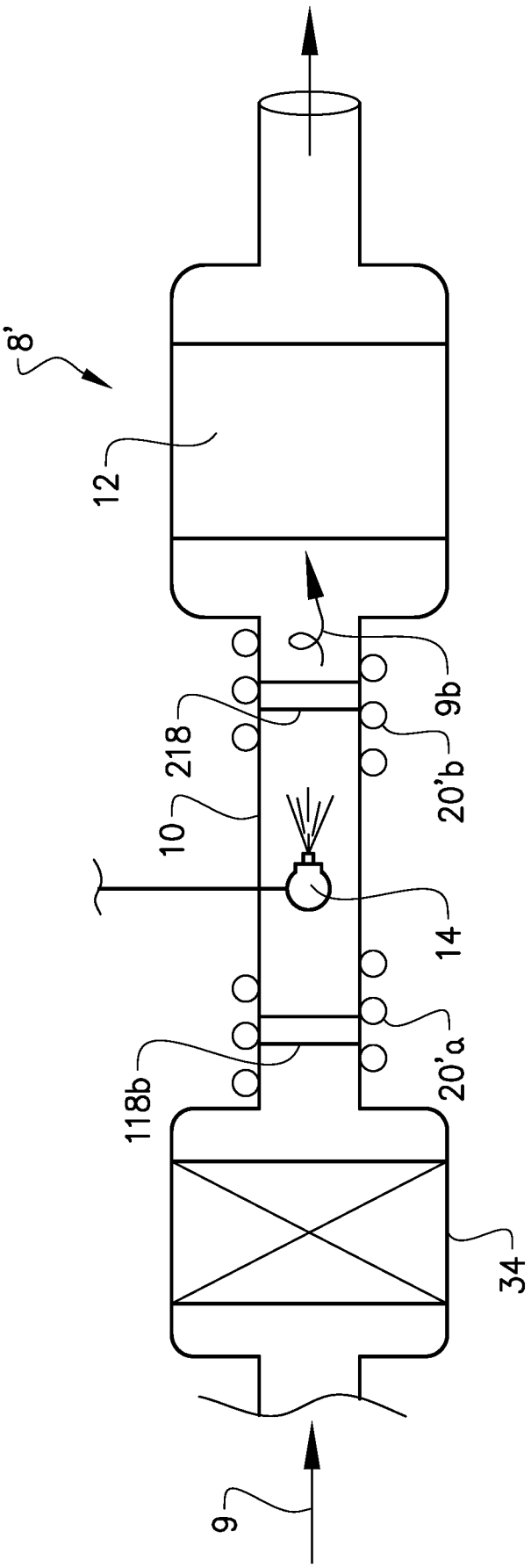


FIG. 34

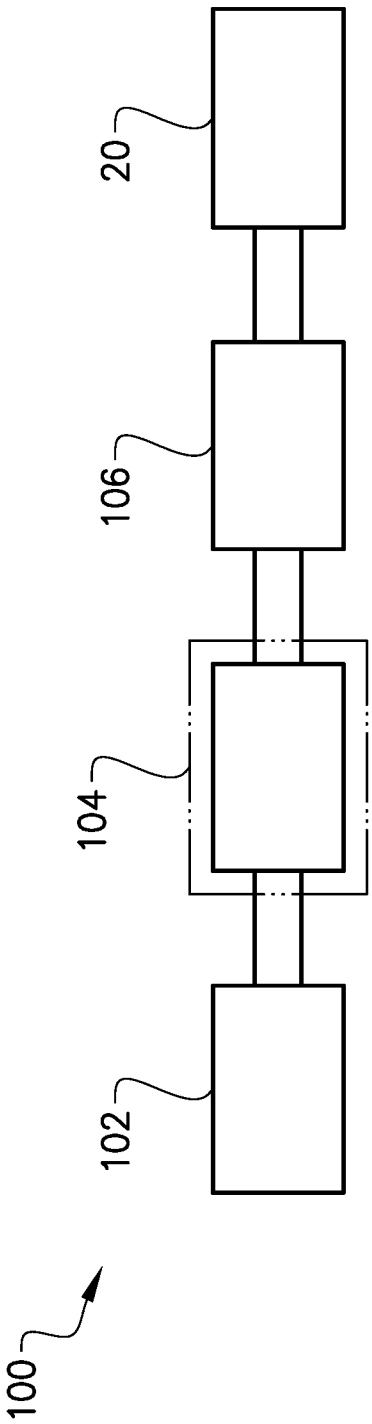


FIG. 35

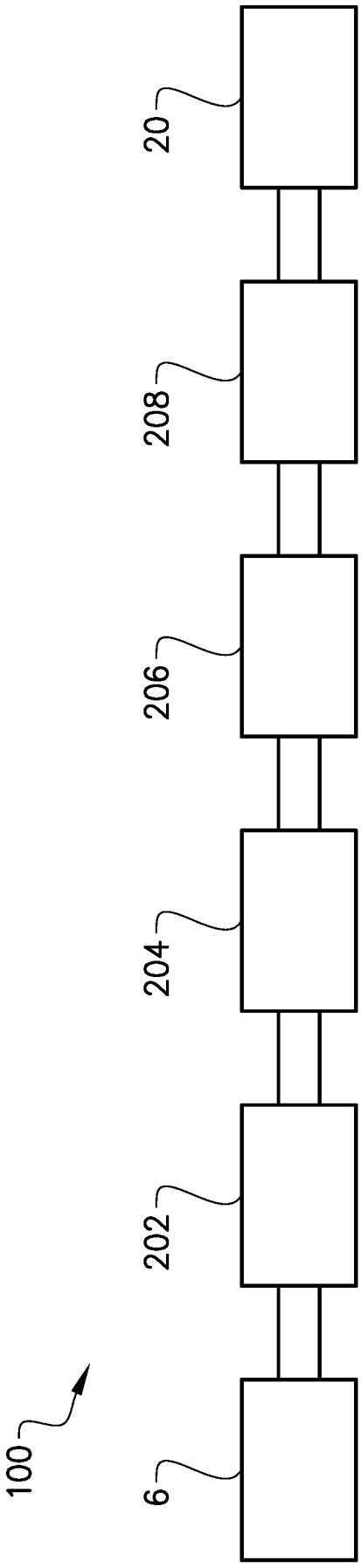


FIG. 36

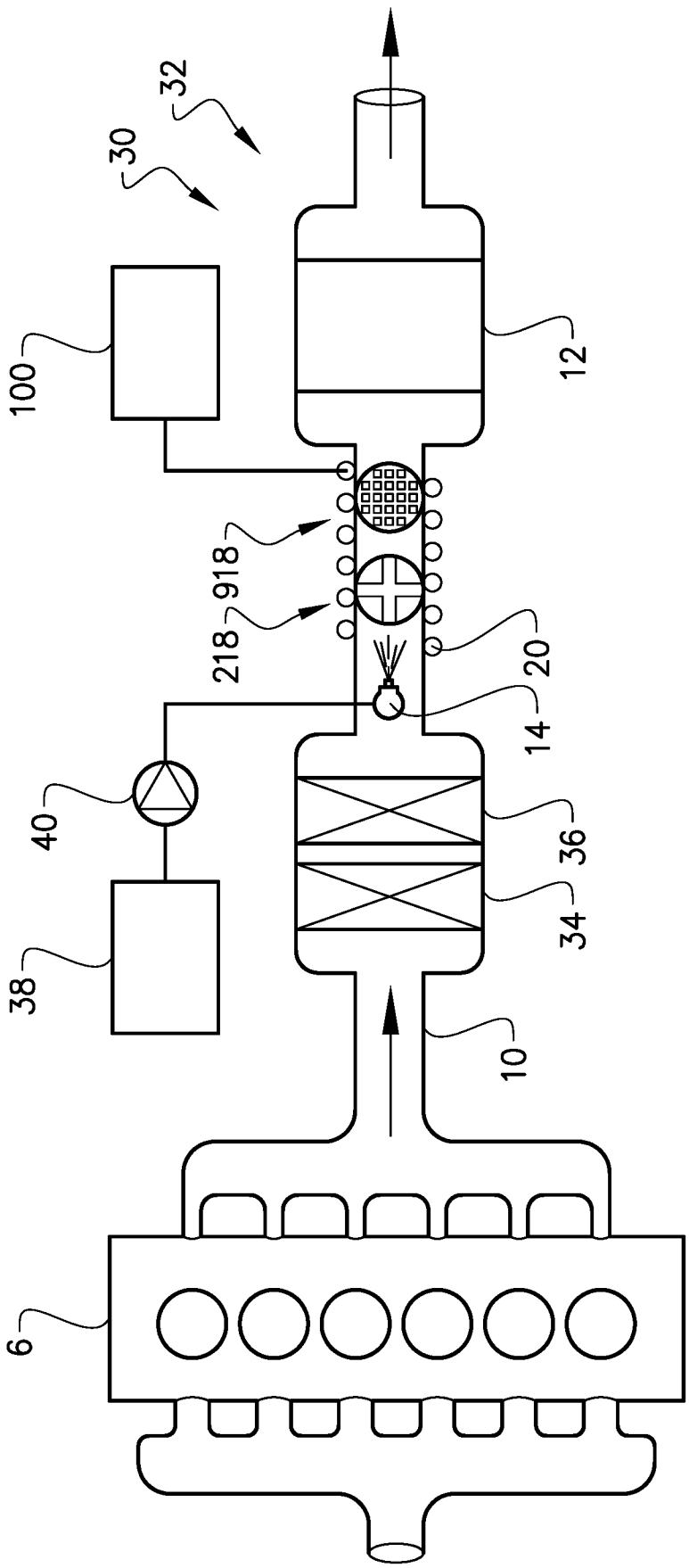


FIG. 37

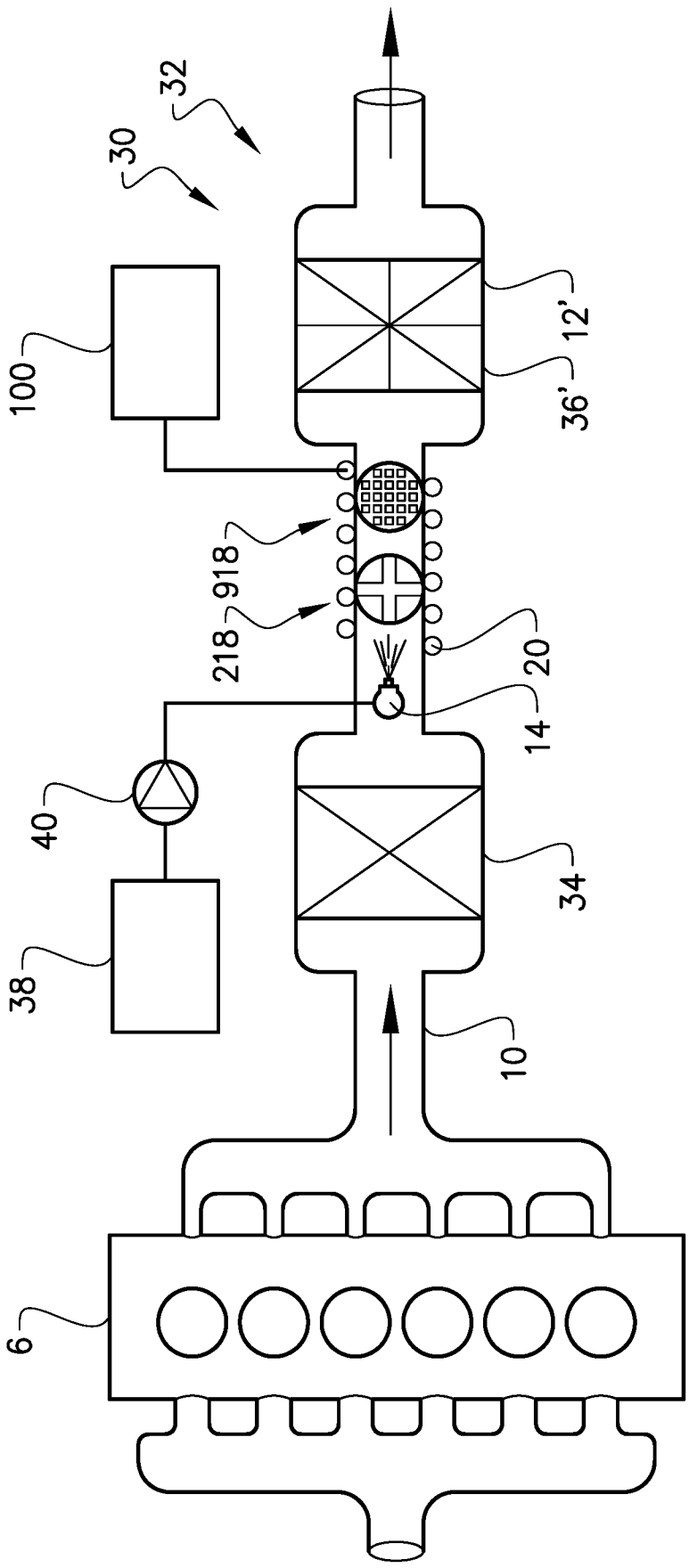
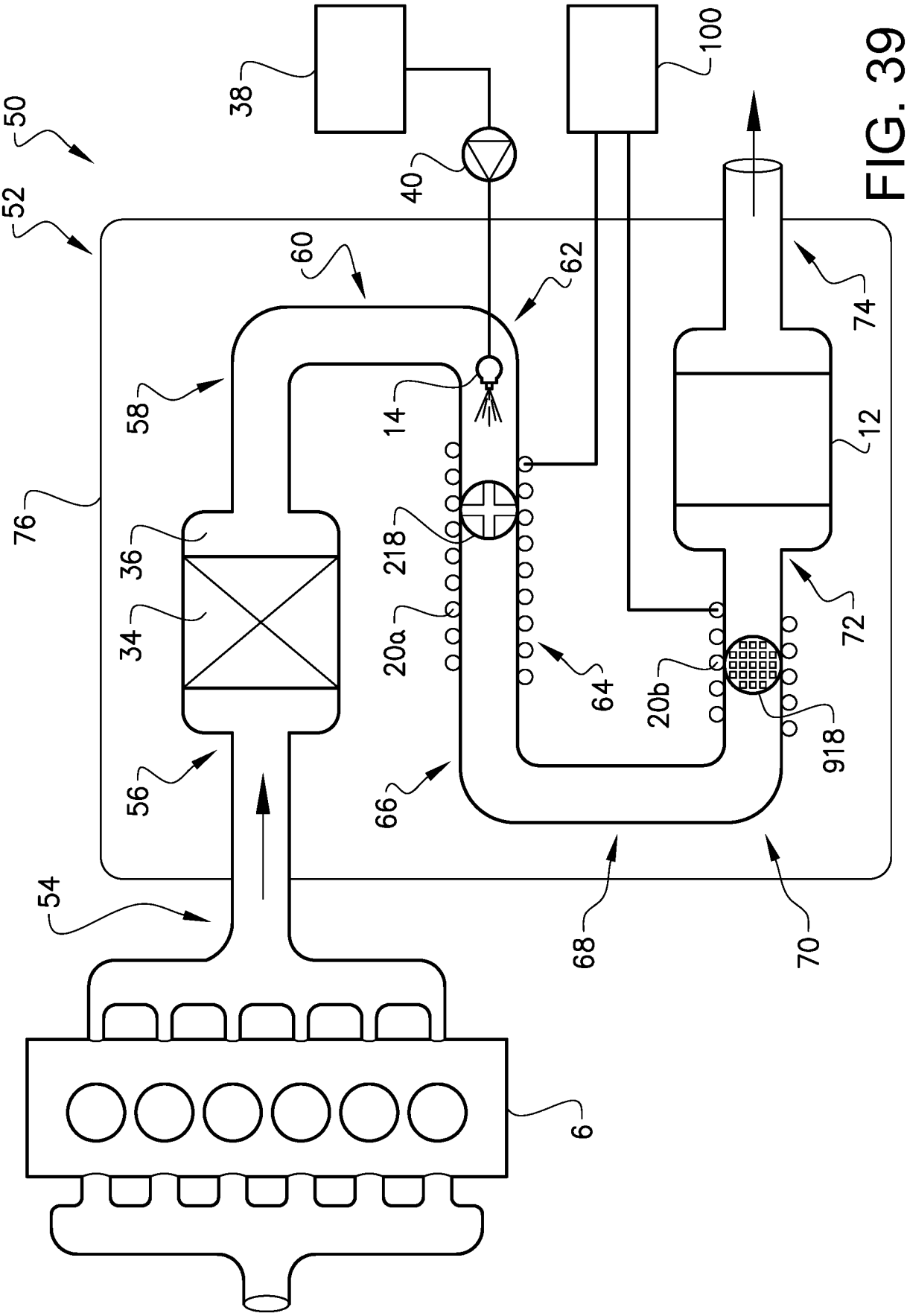


FIG. 38


50
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34
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20b
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918
56
66
54
68
70
6

FIG. 39

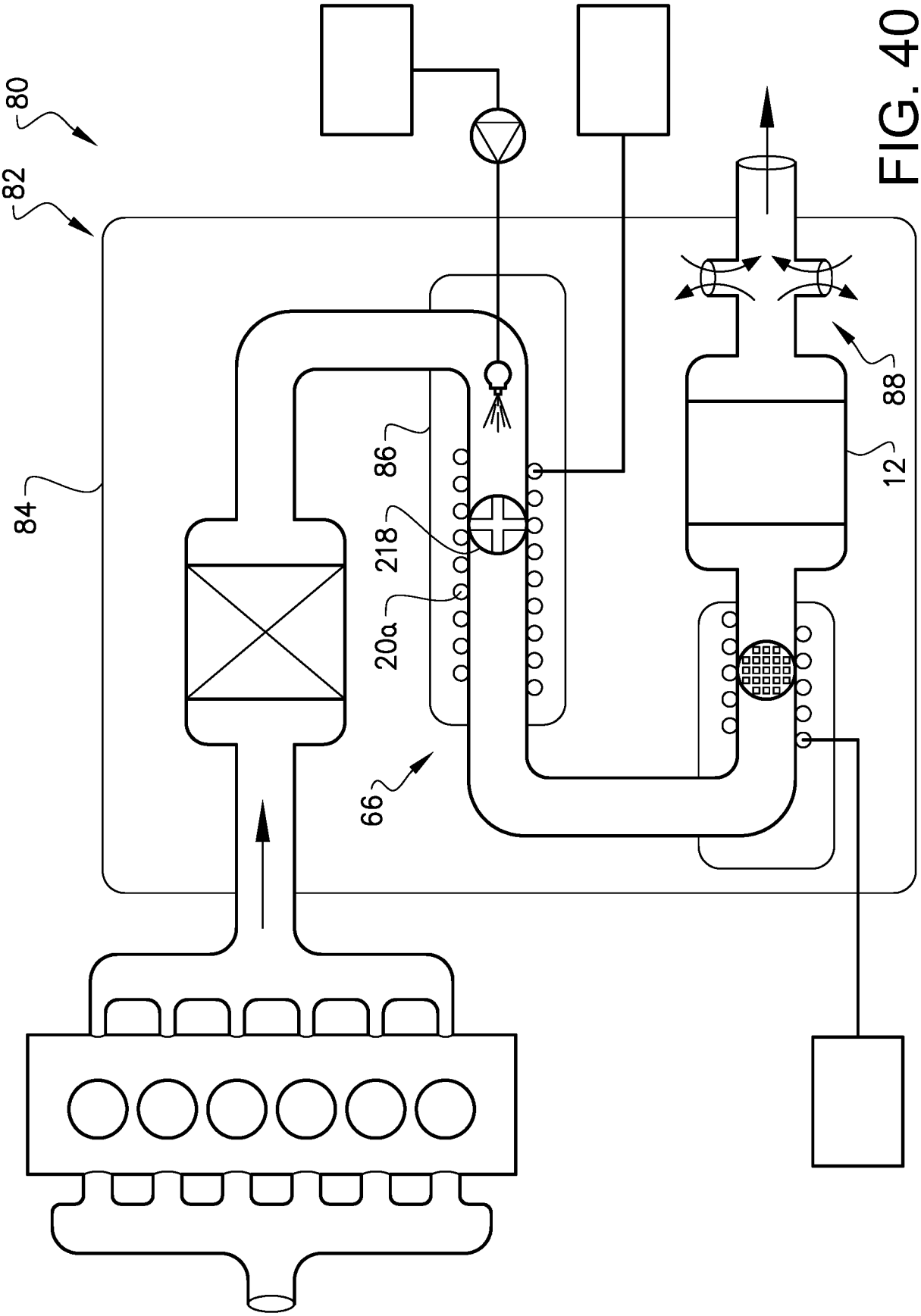

FIG. 40

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/071929

A. CLASSIFICATION OF SUBJECT MATTER
INV. F01N3/20 F01N3/32 F01N3/30 F01N3/28 B01F5/00
F01N9/00
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F01N B01F

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2015/110678 A1 (STELZER ROBERT M [CA]) 23 April 2015 (2015-04-23) paragraph [0017]; figure 2	1,17,18, 23-25
A	EP 2 918 805 A1 (TOYOTA MOTOR CO LTD [JP]) 16 September 2015 (2015-09-16) paragraph [0006] paragraph [0121] - paragraph [0122] paragraph [0125]; figure 16	1,2,5-7, 12-14, 17,23-25
A	JP H08 28250 A (SHIMADZU CORP) 30 January 1996 (1996-01-30) abstract; figure 1	1,3,4, 23-25
A	JP H08 326522 A (SETA GIKEN KK; OMRON TATEISI ELECTRONICS CO; HATANAKA YOSHIHIRO) 10 December 1996 (1996-12-10) abstract; figure 1	1,3,4, 23-25

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 October 2016	12/01/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Zebst, Marc

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2016/071929

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-18, 23-25

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-18, 23-25

A method for controlling an exhaust gas treatment system (8) arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit (10), and a selective catalytic reduction catalyst (12) provided in the exhaust conduit (10),characterized byproviding (S4, S102, S203) an alternating current through an electric conduit (20) located externally of the exhaust conduit (10), thereby providing induction heating of a portion (101, 118, 218, 318, 418, 518, 618, 718, 818, 918, 1018) of the exhaust conduit located upstream of the catalyst (12), and supplying (S5, S107), into the exhaust conduit (10), a reductant for an exhaust gas treatment process in the catalyst (12).

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2. claims: 19-22, 26-30

A method for controlling an exhaust gas treatment system (8) arranged to receive exhaust gases from an internal combustion engine, the system comprising an exhaust conduit (10),characterized by supplying (S204) compressed air into the exhaust conduit (10).

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/071929

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015110678 A1	23-04-2015	NONE	
EP 2918805 A1	16-09-2015	CN 104769244 A	08-07-2015
		EP 2918805 A1	16-09-2015
		JP 5880731 B2	09-03-2016
		JP WO2014073408 A1	08-09-2016
		US 2015314239 A1	05-11-2015
		WO 2014073408 A1	15-05-2014
JP H0828250 A	30-01-1996	NONE	
JP H08326522 A	10-12-1996	JP 3602204 B2	15-12-2004
		JP H08326522 A	10-12-1996