(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 491 935 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
15.01.2025 Bulletin 2025/03

(21) Application number: **23315280.0**

(22) Date of filing: **12.07.2023**

(51) International Patent Classification (IPC):
F17C 13/02 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F17C 13/02

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC ME MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA
Designated Validation States:
KH MA MD TN

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(54) **METHOD FOR OPERATING A FUEL DISPENSING SYSTEM AND FUEL DISPENSING SYSTEM**

(57) The invention relates to a method for operating a fuel dispensing system (110), wherein the fuel dispensing system comprises a fuel dispensing apparatus (120), a fuel supply system (130), and a cooling system (140), wherein the fuel dispensing apparatus is configured to dispense the fuel to a fuel receiver (160), wherein the cooling system is configured to cool down at least part of the fuel supply system and/or of the fuel dispensing apparatus, wherein the fuel dispensing system further comprises a presence sensor (152), wherein the method comprises: receiving sensor information from the presence sensor; detecting, based on the sensor information, presence of a fuel receiver; and causing the cooling system cool down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus dispensing fuel apparatus, depending on the detection of the presence of a fuel receiver.

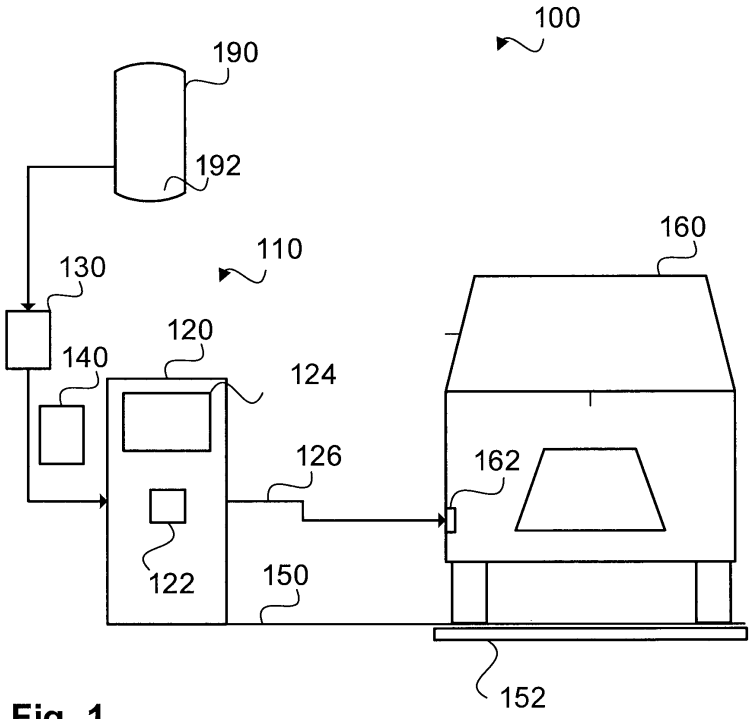

Fig. 1

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Description

[0001] The present invention relates to a method for operating a fuel dispensing system for dispensing fuel, preferably cryogenic fuel like hydrogen, to a fuel dispensing system and to a cryogenic fuel station, for, e.g., hydrogen or natural gas.

Background

[0002] Vehicles like trucks, buses, vans or cars can be powered with cryogenic fuels. Hydrogen, for example, must be kept at a cryogenic temperature for storing and dispensing it into the vehicle. This also requires cooling down the dispensing equipment before any dispensing operation.

[0003] Cooling down such equipment, in particular to very low temperatures, can take a long time. Thus, an improved way of providing fuel like hydrogen or other cryogenic fuel is an objection of the present invention.

Disclosure of the invention

[0004] This object is achieved by providing a method for operating a fuel dispensing system, a fuel dispensing system, a cryogenic fuel station, and a data processing device with the features of the independent claims. Embodiments of the invention are the subject of the dependent claims and of the description that follows.

[0005] The invention relates to fuel dispensing systems used for dispensing fuels like hydrogen (H2), natural gas (NG or LNG, liquefied natural gas) or other cryogenic fuels to fuel receivers like vehicles, e.g., trucks, buses, vans or cars. Typically, such fuel dispensing systems are used in fuel stations like hydrogen fuel stations or other cryogenic fuel stations. Cryogenic fuels (or also other types of fuels) are typically stored in a reservoir at a fuel dispensing station or the like; in the reservoir, the fuel is held at low (cryogenic) temperatures, e.g., 20 K. Such fuel also has to be transferred to a fuel dispensing apparatus (often only called dispenser), e.g., via pumps or another fuel supply system, via the fuel dispensing apparatus the fuel can be transferred to the fuel receiver. Due to the low temperature of the fuel, the fuel supply system and/or fuel dispensing apparatus, or at least parts thereof, have also to be cooled down. A cooling system can be provided for that.

[0006] At a fuel station, users typically arrive with their vehicle, park the vehicle at the fuel dispensing apparatus (dispenser), connect the fuel dispensing apparatus with the vehicle, and start dispensing or cause the fuel dispensing apparatus to do so. Depending on the type of fuel dispensing station, payment has to be made prior to the start of dispensing.

[0007] While for other fuel types like petroleum or diesel, dispensing can start immediately after connecting (or, as the case may be, after payment), this can be different for fuel dispensing system where parts have to be cooled down. In order to prevent boil off gas in the reservoir of the fuel, and also to save energy and costs, cooling down of the fuel supply system and the fuel dispensing apparatus is stopped after a certain time period of no dispensing. This, however, also means that, in such case, the fuel supply system and/or fuel dispensing apparatus, or at least parts thereof, have to be cooled down again if a next user arrives for dispensing fuel. A time period until the parts have sufficiently be cooled down may be up to 15 min. This results in a long waiting time for the user. In addition, this may cause the user to become careless as to connecting the fuel dispensing apparatus or the like.

[0008] Within the present invention, it is suggested to use a presence sensor, i.e. the fuel dispensing system comprises - in addition to the fuel dispensing apparatus, the fuel supply system, and the cooling system - such presence sensor. Based on sensor information received from the presence sensor, e.g., at a processing device of the fuel dispensing system or the fuel dispensing apparatus, a fuel receiver like the vehicle can be detected. This means that, based on the sensor information, it can be determined whether a fuel receiver is present, e.g., within a pre-defined area. Such pre-defined are can be, for example, a vehicle lane next to the fuel dispensing apparatus. Such fuel dispensing system is, thus, configured to detect presence of a fuel receiver like a vehicle by means of the presence sensor.

[0009] Such presence sensor, for example, is capable of or configured to detect the presence of a vehicle within at least a pre-defined distance from the sensor. Preferred presence sensors that can be used are an inductive sensor (e.g., in form of or comprising a inductance loop), an infrared sensor, an ultrasound sensor, a video camera, a mechanical sensor (e.g., weight sensor). Also, two or more of them in combination could be used, be it of different or the same type. The presence sensor can, for example, be of an analogue type, i.e., it will provide an electrical analogue signal indicating whether or not a vehicle is present. Preferably, the presence sensor is designed or configured for outdoor atmosphere, a minimum recommendation is, for example, -20°C to 60°C to reach a large number of countries. Preferably, the presence sensor is also designed or configured for explosive atmosphere. Preferably, the presence sensor is also in accordance with local norms or other requirements (e.g., ATEX for Europe, IECex for Australia, UL for USA, CSA for Canada, GOSTR-EX for Russia). A minimum distance range of detection, for the presence sensor, has to be, for example, between 0 mm and 1000 mm.

[0010] The cooling system is then caused to cool down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus dispensing fuel apparatus, depending on the detection of the presence of a fuel. In an embodiment, it is detected, based on the sensor information, whether the fuel receiver is present within a pre-defined area with respect to the fuel dispensing system, and/or for at least a pre-defined time period.

The cooling system is caused to start cooling down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus, if the fuel receiver is present within said pre-defined area and/or for at least said pre-defined time period. Such pre-defined time period can be 10 or 15 seconds, for example. With using such time period unnecessary cool down can be prevented if a vehicle just drives by, for example. For a truck of 15 meters length and a velocity of 10 km/h, for example, it takes about 6 seconds to pass a certain location like the presence sensor. This means that if the vehicle is detected for at least 10 seconds, for example, the vehicle will most likely having been stopped or parked.

[0011] In an embodiment, the cooling system is further caused to stop cooling down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus dispensing fuel apparatus, if the fuel receiver is not present within said pre-defined area and/or for at least a further pre-defined time period, after cooling down had been started. In this way, energy can be saved if no more vehicle is present to be fuelled.

[0012] In an embodiment, the fuel dispensing apparatus is caused to start dispensing the fuel to said fuel receiver upon receiving a user input. For example, the user (e.g., the driver of the vehicle to be fuelled) can be required to push a start button after having connected the fuel dispensing apparatus to the vehicle and, as the case may be, after having made a payment at the fuel station.

[0013] The invention also relates to a data processing device comprising or processor or other means for performing the method according to the invention or method steps thereof. The data processing device may be a computer or server, for example in a so-called cloud or cloud environment.

[0014] The implementation of a method according to the invention in the form of a computer program or computer program product with program code or instructions for performing all method steps is also advantageous, since this causes particularly low costs, in particular if an executing control device is still used for further tasks and is therefore present anyway. Also, a machine-readable storage medium is provided with a computer program or instructions stored thereon as described above. Suitable storage media or data carriers for providing the computer program are in particular magnetic, optical and electrical memories, such as hard disks, flash memories, EEPROMs, DVDs and the like. It is also possible to download a program via computer networks (Internet, intranet, etc.). Such a download can take place by wire or cable or wirelessly (e.g. via a WiFi network, a 3G, 4G, 5G or 6G connection, etc.).

[0015] Further advantages and embodiments of the invention will become apparent from the description and the appended figures.

[0016] It should be noted that the previously mentioned features and the features to be further described in the following are usable not only in the respectively indicated combination, but also in further combinations or taken alone, without departing from the scope of the present invention.

Short description of the figures

[0017]

Fig. 1 illustrates a fuel dispensing apparatus according to a preferred embodiment of the invention;

Fig. 2 illustrates a fuel dispensing apparatus according to another preferred embodiment of the invention; and

Fig. 3 illustrates a method according to a preferred embodiment of the invention in a flow diagram.

Detailed description of the figures

[0018] Fig. 1 schematically illustrates a cryogenic fuel station 100 according to a preferred embodiment of the invention. The fuel station 100 comprises a fuel dispensing system 110, wherein the fuel dispensing system 110 comprises a fuel dispensing apparatus (fuel dispenser) 120, a fuel supply system 130, and a cooling system 140. The fuel station 100 further comprises a reservoir 190 for cryogenic fuel 192, e.g., hydrogen.

[0019] The fuel supply system 130 is configured to provide the fuel 192 from the reservoir 190 to the fuel dispensing apparatus 120. For example, the fuel supply system can comprise a pump and corresponding transfer or supply lines. The fuel dispensing apparatus 120 is configured to dispense the fuel to a cryogenic fuel receiver 160, e.g. a vehicle like a truck or, in particular, a fuel tank thereof.

[0020] The fuel dispensing apparatus 120, in an embodiment, comprises a data processing device 122, and a display 124. Further, the fuel dispensing apparatus 100 comprises a hose 126 configured to be coupled to an interface 162 of the fuel receiver 160. The fuel dispensing apparatus 120 is configured to dispense fuel via the hose 126 to the fuel receiver 160 or its tank, via the interface 162.

[0021] The cooling system 140 is configured to cool down at least part of the fuel supply system 130 and/or at least part of the fuel dispensing apparatus 120. For example, all components of the fuel supply system 130 and the fuel dispensing apparatus 120, which come into contact with the fuel, can be cooled down. Cooling can be done in many ways. For example, for LNG and LH2, a cooling loop (190;130;120 and back to 190) can be used. For example, for GH2, a combination with a chiller (out of dispensing system) and an exchanger (liquid / gas) (into the dispenser) in order to supply a cooled hydrogen (standard setpoint: -40°C) can be used.

[0022] Further, the fuel dispensing system 110 comprises a presence sensor 152. In an embodiment, the presence sensor 152 is or comprises or makes use of an

induction coil. Such induction coil, for example, can be integrated into a floor or ground 150, on which the fuel receiver 160 is to be parked for fuelling and on which the fuel dispensing apparatus 120 is located. The presence sensor 152 can be connected to the data processing device 122, for example.

[0023] The data processing device 122 can be configured to operate the fuel dispensing system 110, in particular according to a method according to a preferred embodiment of the invention, in particular with receiving sensor information from the presence sensor 150. In this way, it is possible to detect presence of the fuel receiver 160 at the fuel dispensing apparatus 120. Instead of an induction coil, the presence sensor could also be of another type of sensor capable of determining the presence of the fuel receiver 160, preferably, within at least a pre-defined distance from the sensor, e.g., using a video camera, infrared sensor, an ultrasound sensor, a mechanical sensor or another type of inductive sensor. With a video camera, for example, the captured video can be analyzed as to the presence of a vehicle.

[0024] The fuel dispensing system 110 is configured to detect presence of a fuel receive 160 like the truck shown in Fig. 1 by means of the presence sensor 152, and the fuel dispensing system 110 is further configured to cool down the at least part of the fuel supply system 130 and/or at least part of the fuel dispensing apparatus 120, by means of the cooling system 140, depending on the detection of the presence of a fuel receiver 160, e.g., the truck shown in Fig. 1.

[0025] Fig. 2 schematically illustrates a cryogenic fuel station 200 according to another preferred embodiment of the invention. The fuel station 200 is shown in a top view. Only some parts of the fuel station 200 are shown for explanation. The fuel station 200 comprises, by means of example, three fuel dispensing systems 210a, 210b, 210c with corresponding vehicle lanes 264a, 264b, 264c, indicated with arrows and markings on the ground, for example. Each of the fuel dispensing systems 210a, 210b, 210c comprises a respective a fuel dispensing apparatus 220a, 220b, 220c.

[0026] Each of the fuel dispensing systems 210a, 210b, 210c can be supplied with fuel via a respective fuel supply system from a reservoir (not shown here). A common reservoir for all fuel dispensing systems can be used. Also, each of the fuel dispensing systems 210a, 210b, 210c can comprise a respective cooling system (not shown here). Further, each of the fuel dispensing systems 210a, 210b, 210c comprises a presence sensor 252a, 252b, 252c in order to detect presence of a fuel receiver, e.g., truck 260 shown here. For example, a pre-defined area 254a, 254b, 254c can be defined, each being a part of the respective vehicle lane 264a, 264b, 264c next to the respective fuel dispensing apparatus 220a, 220b, 220c.

[0027] Each of the fuel dispensing systems 210a, 210b, 210c can be of the same type and/or operate in the same way as the fuel dispensing system 110 shown in Fig. 1 and described above. By means of example, however, different presence sensors are shown in Fig. 2. Presence sensor 252a is an inductive sensor (like for Fig. 1), presence sensor 252b is a video camera, and presence sensor 252c is a mechanical sensor. Each of the presence sensors allows detecting presence of a fuel receiver like the vehicle or truck 260 being present in the respective defined area 254a, 254b, 254c

[0028] Fig. 3 illustrates a method according to a preferred embodiment of the invention in a flow diagram. This method can be carried out with the fuel dispensing system 110 of Fig. 1 or with each of the fuel dispensing systems 210a, 210b, 210c of Fig. 2, for example.

[0029] In step 300, sensor information from the presence sensor are received. In step 302, based on the sensor information, presence of a fuel receiver is detected, if any fuel receiver can be detected. For example, a fuel receiver is detected to be present if a fuel receiver is present within a pre-defined area with respect to the fuel dispensing system, e.g., the vehicle lanes or parts thereof shown in Fig. 2, and/or for at least a pre-defined time period, e.g., 10 seconds.

[0030] In step 304, the cooling system is caused cool down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus dispensing fuel apparatus. It is noted that in this way the equipment can be cooled down prior to the actual start of the fuel dispensing. After the fuel receiver or vehicle has stopped, the user can make a payment, connect the fuel dispensing apparatus of the vehicle and then push a button to start the fuel dispensing. Thus, in step 306, the fuel dispensing apparatus is caused to start dispensing the fuel to said fuel receiver upon receiving a user input.

[0031] Further, in step 308, the cooling system is caused to stop cooling down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus dispensing fuel apparatus. This is the case, if the fuel receiver is not present within said pre-defined area and/or for at least a further pre-defined time period, after cooling down had been started. For example, after a vehicle has been fuelled and left the fuel station and if for a certain time no further vehicle arrives in the same vehicle line, the cooling down will be stopped for energy savings.

Claims

1. A method for operating a fuel dispensing system (110, 210a, 210b, 210c), wherein the fuel dispensing system comprises (110, 220a, 220b, 220c) a fuel dispensing apparatus (120, 220a, 220b, 220c), a fuel supply system (130), and a cooling system (140),

   wherein the fuel supply system (130) is configured to provide fuel (192), preferably cryogenic fuel, from a reservoir (190) to the fuel dispensing apparatus (120, 220a, 220b, 220c),
   wherein the fuel dispensing apparatus (120) is

configured to dispense the fuel (192) to a fuel receiver (160, 260),
wherein the cooling system (140) is configured to cool down at least part of the fuel supply system (130) and/or at least part of the fuel dispensing apparatus (120, 220a, 220b, 220c),
wherein the fuel dispensing system (110, 210a, 210b, 210c) further comprises a presence sensor (152, 252a, 252b, 252c),
wherein the method comprises:

receiving (300) sensor information from the presence sensor;
detecting (302), based on the sensor information, presence of a fuel receiver; and
causing (304) the cooling system cool down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus dispensing fuel apparatus, depending on the detection of the presence of a fuel receiver.

2. The method of claim 1, further comprising: detecting, based on the sensor information, whether the fuel receiver is present within a pre-defined area (254a, 254b, 254c) with respect to the fuel dispensing system, and/or for at least a pre-defined time period; and causing the cooling system to start cooling down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus, if the fuel receiver is present within said pre-defined area and/or for at least said pre-defined time period.

3. The method of claim 2, further comprising: causing (308) the cooling system to stop cooling down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus dispensing fuel apparatus, if the fuel receiver is not present within said pre-defined area and/or for at least a further pre-defined time period, after cooling down had been started.

4. The method of claim 2 or 3, wherein the pre-defined area is a vehicle lane (264a, 264b, 264c) next to the fuel dispensing apparatus or a part of said vehicle lane.

5. The method of any one of the preceding claims, further comprising: causing (306) the fuel dispensing apparatus to start dispensing the fuel to said fuel receiver upon receiving a user input.

6. The method of any one of the preceding claims, wherein the presence sensor is configured to detect the presence of a vehicle within at least a pre-defined distance from the sensor.

7. The method of any one of the preceding claims, wherein the presence sensor is one of the following sensors: an inductive sensor (152, 252a), an infrared sensor, an ultrasound sensor, a video camera (252b), a mechanical sensor (252c).

8. The method of any one of the preceding claims, wherein cryogenic fuel, preferably hydrogen or natural gas, is used as the fuel.

9. A data processing device (122) comprising a processor configured to perform the steps of any one of the preceding claims.

10. A fuel dispensing system (110, 210a, 210b, 210c), comprising a fuel dispensing apparatus (120, 220a, 220b, 220c), a fuel supply system (130), and cooling system (140), wherein the fuel supply system (130) is configured to provide fuel (190), preferably cryogenic fuel, from a reservoir (190) to the fuel dispensing apparatus (120), wherein the fuel dispensing apparatus (120) is configured to dispense the fuel to a fuel receiver (160), 260), wherein the cooling system (140) is configured to cool down at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus,

wherein the fuel dispensing system (110, 210a, 210b, 210c) further comprises a presence sensor (152, 252a, 252b, 252c), wherein fuel dispensing system is configured to detect presence of a fuel receiver by means of the presence sensor, and
wherein the fuel dispensing system (110, 210a, 210b, 210c) is configured to cool down the at least part of the fuel supply system and/or at least part of the fuel dispensing apparatus, by means of the cooling system, depending on the detection of the presence of a fuel receiver.

11. The cryogenic fuel dispensing system (110, 210a, 210b, 210c) of claim 10, further comprising the data processing device of claim 9.

12. A cryogenic fuel station (100, 200) comprising the cryogenic fuel dispensing system (110, 210a, 210b, 210c) of claim 10 or 11.

13. A computer program comprising instructions which, when the program is executed by a computer, cause the computer to perform the steps of the method of any one of claims 1 to 8.

14. A computer-readable storage medium comprising instructions which, when executed by a computer, cause the computer to perform the steps of the method of any one of claims 1 to 8.

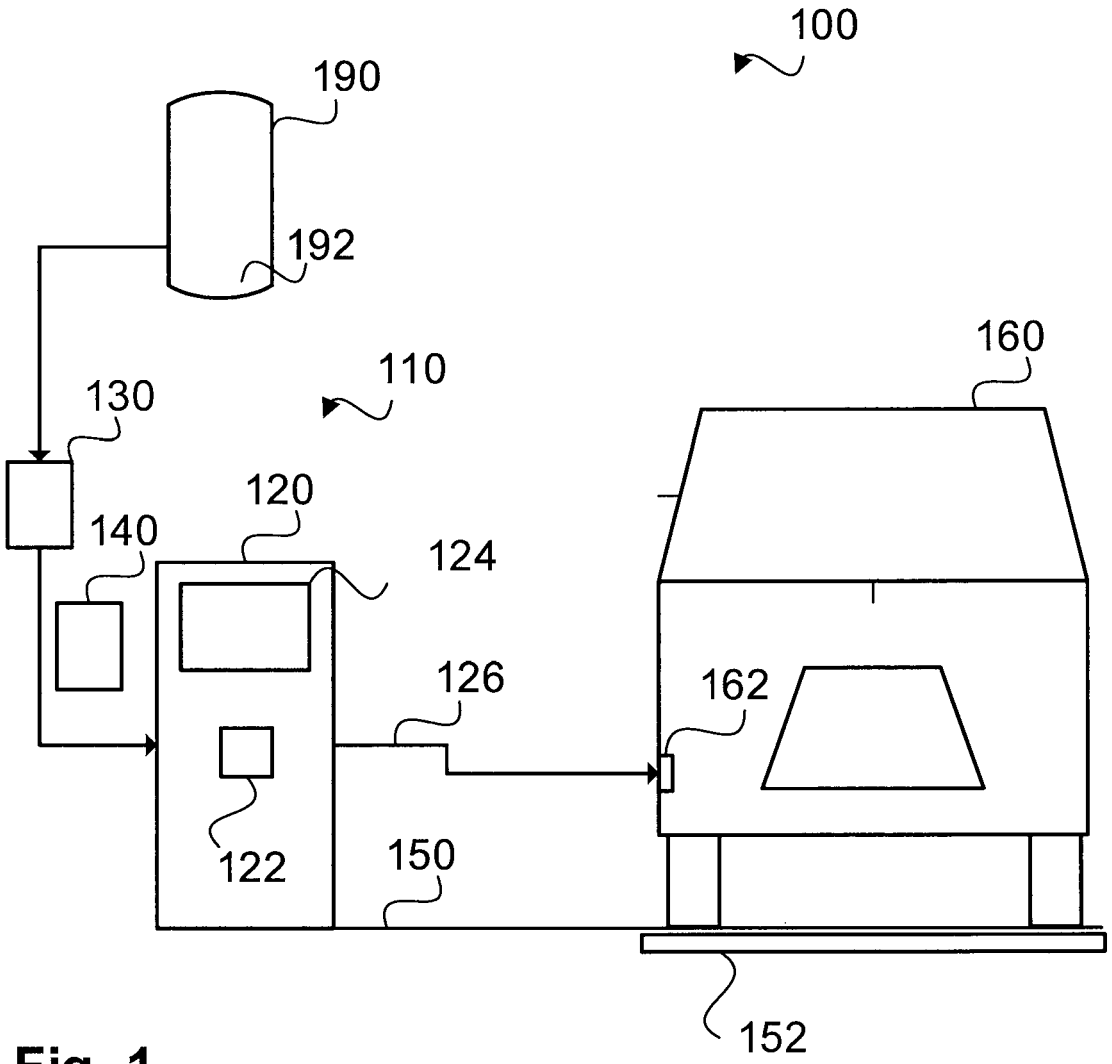

Fig. 1

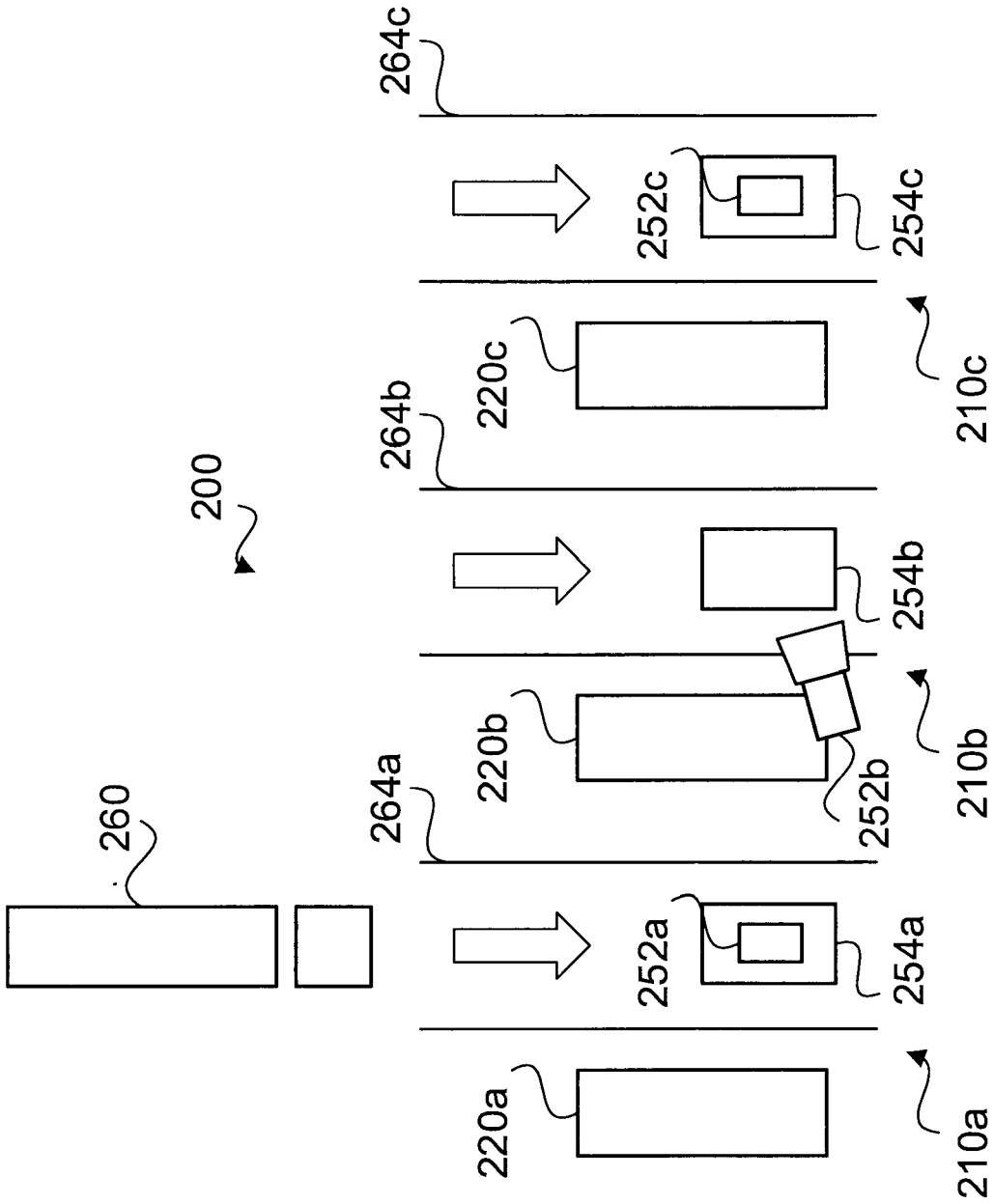
200
260
264a
264b
264c
220a
220b
220c
210a
210b
210c
252a
252b
252c
254a
254b
254c

Fig. 2

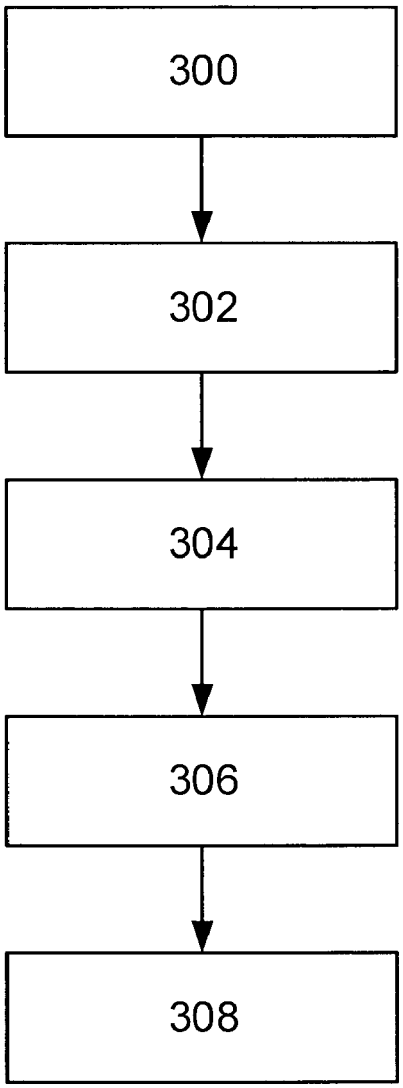

Fig. 3

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EUROPEAN SEARCH REPORT

Application Number
EP 23 31 5280

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	JP 2017 187057 A (TATSUNO CORP) 12 October 2017 (2017-10-12) * paragraphs [0001], [0021], [0034], [0036]; figures *	1-14	INV. F17C13/02
X	US 2012/125482 A1 (MORI TOMOYUKI [JP]) 24 May 2012 (2012-05-24) * paragraphs [0016], [0031], [0042]; figures *	1,3,4,9, 10,13,14	
A	CN 114 466 989 A (BMW SHARE COMPANY) 10 May 2022 (2022-05-10) * claim 1; figures *	1-14	
A	EP 4 119 493 A1 (ME ENERGY GMBH [DE]) 18 January 2023 (2023-01-18) * figures *	1-14	

TECHNICAL FIELDS SEARCHED (IPC)

F17C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	7 December 2023	Pöll, Andreas

CATEGORY OF CITED DOCUMENTS

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07-12-2023

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
JP 2017187057 A	12-10-2017	JP 6338203 B2	06-06-2018
		JP 2017187057 A	12-10-2017
		KR 20170113077 A	12-10-2017
US 2012125482 A1	24-05-2012	CN 102472431 A	23-05-2012
		DE 112010003119 T5	14-03-2013
		JP 5474436 B2	16-04-2014
		JP 2011033068 A	17-02-2011
		US 2012125482 A1	24-05-2012
		WO 2011012937 A1	03-02-2011
CN 114466989 A	10-05-2022	CN 114466989 A	10-05-2022
		DE 102019126878 A1	08-04-2021
		WO 2021069412 A1	15-04-2021
EP 4119493 A1	18-01-2023	DE 102021118322 A1	19-01-2023
		EP 4119493 A1	18-01-2023

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