

(19)



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(11) Publication number:

**0 551 554 A1**

(12)

**EUROPEAN PATENT APPLICATION**(21) Application number: **92107433.2**(51) Int. Cl.<sup>5</sup>: **B61C 3/00, B61C 17/00,  
H01F 27/20**(22) Date of filing: **30.04.92**(30) Priority: **17.01.92 JP 6881/92**(43) Date of publication of application:  
**21.07.93 Bulletin 93/29**(84) Designated Contracting States:  
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W-8000 München 86 (DE)**(54) **Cooling system for electric car mounting transformer.**

(57) For obtaining an incombustible and safe cooling system for an electric car mounting transformer in which the cooler installation position in the electric car is not limited, the cooling system comprising a cooler 23 for refrigerant 25 for cooling a transformer 21, and a circulating blower 22 disposed in a pipe 24 connected between the transformer 21 and the cooler 23 for circulating the refrigerant between the transformer and the cooler is arranged such that the refrigerant 24 is an SF<sub>6</sub> gas and that the cooler is mounted to electric car body side wall, top wall or

front and rear end walls so that it is cooled by a fan or running wind. Therefore, the cooling system is incombustible, mounting space for another electrical equipment increases and the degree of freedom of cooler lay out increases. Also, noise can be reduced by disposing a gas circulating blower within the transformer tank, and refrigerant gas filling operation in site is made unnecessary by providing the refrigerant pipe with connection portions capable of being opened and closed.

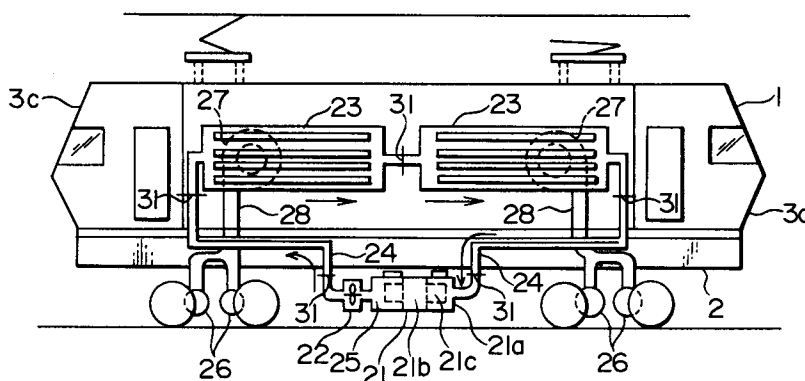
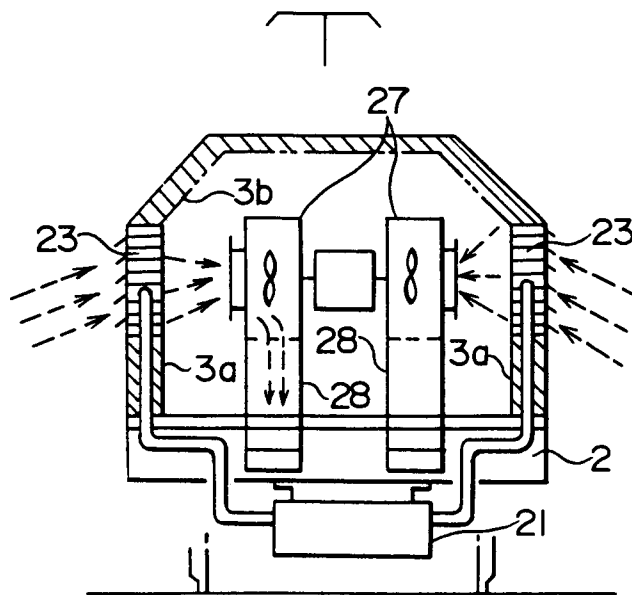
**FIG. 1****EP 0 551 554 A1**

FIG. 2



## INDUSTRIAL FIELD OF APPLICATION

This invention relates to a cooling system for a transformer to be mounted on an electric car such as an electric locomotive.

## PRIOR ART

Figs. 12 and 13 illustrate a conventional cooling system for an electric car mounting transformer disclosed for example in "Electrical Equipment of the Three-Phase DB Class E 120 Universal Main-Line Locomotive" Rail Engineering International, July/September 1979, in which reference numeral 1 is an electric car such as an electric locomotive, 2 is a floor which is a base frame of the electric car 1, 3 is a car body wall or a frame of the electric car 1 and has side walls 3a, a top wall 3b and front and rear walls 3c. Reference numeral 11 is a transformer mounted to the bottom surface of the floor 2, 12 is a oil circulating pump, 13 is an oil cooler installed on the floor 2 of the electric car, 14 are oil supply pipes and 15 is an electrically insulating cooling oil. Also, reference numeral 16 is a fan for the oil cooler, 17 is an air duct for allowing atmosphere air to flow from the bottom of the floor through the oil cooler 13 and to be discharged from the top wall 3b, 18 is a conservator, and 19 are various electric equipments other than the transformer.

In Figs. 12 and 13, during the operation of the electric car, the heat generated at the transformer 11 is used to heat the cooling oil 15. The cooling oil 15 thus heated to an elevated temperature is supplied through the oil pipe 14 by means of the oil pump 12 to the oil cooler 13, where it is cooled by an air flow from the outside supplied by the fan 16. The external air flow heated by the oil cooler 13 is discharged to the outside through the top wall 3b which is a roof of the car body through the air duct 17. The cooling oil 15 cooled to a lower temperature is supplied through the oil supply pipe again to the transformer 11 to cool the transformer 11. A conservator 18 is provided for accommodating expansion and contraction due to heat of the cooling oil 15.

## PROBLEM TO BE SOLVED BY THE INVENTION

In the conventional cooling system of the electric car mounting transformer thus constructed, the refrigerant used is oil. Therefore, the transformer is classified as incombustible, which is not desirable for the safety against the vehicle fire accidents. Also, since the transformer and the cooler are disposed at separated remote positions, the cooler and the pipes connected between the transformer and the cooler also have fear of fire ac-

cidents. Further, the longer the circulating pipes, heavier the weight of the cooling oil, so that the pipes themselves for supporting the coil increases, resulting in increase of the weight of the entire electric car. Also, since the oil is incompressive, a large conservator for accommodating the expansion and contraction of the cooling oil due to temperature change in the transformer, the cooler and the like, so that the installation of the system into the vehicle body is extremely difficult.

For the above reasons, even when the cooler is separately disposed from the transformer, the cooler in practice must be positioned at relatively close to the transformer, so that the mounting position of the cooler is restricted, leading to a small degree of freedom of the layout design of other electric apparatuses on the electric locomotive.

Accordingly, the object of the present invention is to eliminate the above-discussed problems of the conventional cooling system of the electric car mounting transformer and to provide a cooling system for an electric car mounting transformer in which the cooler is not limited as to its mounting position within the electric car and is relatively freely installed in a space which is not occupied by other apparatuses, and in which the transformer and the transformer cooling system are incombustible and safe.

## MEASURE FOR SOLVING THE PROBLEMS

According to the cooling system for electric car mounting transformer of the present invention, the refrigerant for cooling the transformer is an  $\text{SF}_6$  gas and the cooler for cooling the refrigerant is disposed to the electric car body wall.

According to the present invention, since the refrigerant for cooling the transformer is an  $\text{SF}_6$  gas and the cooler for cooling the refrigerant is disposed to the electric car body wall, the transformer and the cooling system is incombustible and is very high in safety. Also, since the specific weight of the refrigerant is about 1/60 of that of the mineral oil, the weight increase by the increased length of the pipes in the cooling system is small. Further, since the refrigerant is compressible, there is no need for the conservator, whereby the installation of the transformer on the electric car body is not limited even when the pipes are long. Finally, since the cooler can be mounted to the electric car body wall, the cooling of the cooler can be effectively achieved by utilizing the running wind.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will become more clearly understood from the following description of the

embodiments of the present invention taken along the accompanying drawings, in which:

Fig. 1 is a schematic side view of an electric car having the cooling system for an electric car mounting transformer of the present invention;

Fig. 2 is a schematic front view of the electric car shown in Fig. 1;

Fig. 3 is a schematic side view of an electric car having the cooling system for an electric car mounting transformer of the present invention;

Fig. 4 is a schematic front view of the electric car shown in Fig. 3;

Fig. 5 is a schematic perspective view of the electric car having the cooler mounted on the car body top wall;

Fig. 6 is a schematic perspective view of the electric car having the cooler mounted on the car body front and rear end walls;

Fig. 7 is a schematic perspective view of the electric car having the cooler mounted on the car body side walls;

Fig. 8 is a schematic perspective view of the electric car having the heat pipe mounted on the car body side walls;

Fig. 9 is a schematic perspective view illustrating the transformer having the circulating blower self-contained therein;

Fig. 10 is a schematic perspective view illustrating the transformer having only the fan of the circulating blower self-contained therein;

Fig. 11 is a view illustrating the circulating blower shown in Fig. 10;

Fig. 12 is a schematic sectional view illustrating the connection portion of the refrigerant pipe;

Fig. 13 is a schematic side view of the electric car having the conventional cooling system for an electric car mounting transformer; and

Fig. 14 is a schematic front view of the electric car shown in Fig. 13.

## EMBODIMENTS

In Figs. 1 and 2, an electric car 1 such as an electric locomotive comprises a floor 2 which is a car body base frame and a car body wall 3 disposed on the floor 2. The car body wall 3 comprises car body side walls 3a, a car body top wall 3b and car body front and rear end walls 3c. On the bottom surface of the floor 2 of the electric car 1, an electric car mounting transformer 21 is mounted. The transformer 21 comprises an iron core 21b and a coil 21c contained in a tank 21a.

The cooling system of the electric car mounting transformer comprises pipes 24 connected to the tank 21a of the transformer 21 for supplying a refrigerant within the tank 21a to coolers 23 by a circulating blower 22. The pipes 24 are provided with connection portions 31 capable of opening and

closing and opened during the operation as described in more detail later in connection Fig. 12. The refrigerant 25 absorbs the heat from the iron core 21b and the coil 21c of the transformer 21 to cool them. The coolers 23 are for cooling the refrigerant 25 supplied from the pipes 24 after it is heated by the transformer 21. The refrigerant 25 is cooled at the coolers 23 by the external air passing therethrough and supplied to the transformer 21 by the return pipe 24 to cool the transformer 21 again.

In the cooling system for the electric car mounting transformer of the present invention, the refrigerant 25 is an  $\text{SF}_6$  gas. Also, the coolers 23 are disposed to the car body walls 3 of the electric car 1. In the illustrated example, the coolers 23 have a thickness similar to that of the car body side walls 3a and is mounted in an embedded relationship to ventilation openings formed in the both car body side walls 3a, so that they do not decrease the available volume of the compartment defined by the car body walls 3a to 3c. Also, the coolers 23 are disposed within air passages for a fan 27 for supplying the external air through a duct 28 for cooling a main motor 26 mounted under the floor 2. Therefore, the coolers 23 are cooled by the flow of the external air generated by the fan 27, so that a blower only for the purpose of cooling the coolers 23 is not necessary.

Figs. 3 and 4 illustrate another embodiment of the present invention. In this embodiment, the coolers 33 are disposed on the car body top wall 3b. That is, the cooling system of the electric car mounting transformer comprises pipes 34 connected to a tank 31a of a transformer 31 for supplying a refrigerant 35 within the tank 31a to the coolers 33 by means of a circulating blower 32. The refrigerant 35 absorbs the heat from the iron core 31b and the coil 31c of the transformer 31 to cool them. The refrigerant 35 flows through the pipes 34 to the coolers 33 where it is cooled by the external air and supplied through the return pipe 34 to the transformer 31 to cool it.

In the cooling system for the electric car mounting transformer of this embodiment, the coolers 33 are embedded in the car body top wall 3b which is the roof of the electric car 1. In the illustrated example, the coolers 33 are disposed within an air duct 39 for cooling coolers 38 of other electric equipments 36 such as an electric power converter apparatus, so that they are cooled by the external air flow generated in the air duct 39 by a fan 37. Therefore, the compartment volume of the electric car is not occupied by the coolers 33, and the coolers 33 do not need blowers only for them.

While the  $\text{SF}_6$  gas coolers must be larger in size than the oil coolers, since the coolers can be mounted to the car body walls and they do not have to be mounted on the floor, the installation of

other electric apparatuses is not limited, and the available floor space is increased because the space which has heretofore been used for the coolers can be used for other electric apparatuses. Since the car body walls 3 such as the car body side walls 3a or top wall 3b usually have a certain thickness due to the structural members therein, the coolers may be designed to have a thickness similar to or slightly larger than the thickness of the car body walls 3, whereby the coolers can be embedded within the car body walls.

In the cooling system for the electric car mounting transformer of the present invention illustrated in Figs. 5 to 8, the coolers are disposed to the car body walls 3 and running wind intake means for receiving an air flow generated by the running vehicle or the running wind and for generating an air flow through the coolers. Therefore, the cooling fan for the coolers is not necessary, so that the noise from the fan is eliminated, the maintenance and repair of the fan are completely unnecessary, and the electric power for operating the fan is not necessary.

In the example shown in Fig. 5, a plurality of coolers 43 are disposed on the car body top wall 3b to outwardly project from the top surface thereof and they are arranged in a staggered relationship so that each cooler 43 can sufficiently receive a fresh, cold running wind 41 and not the air flow which is exhausted from the preceding cooler 43. The clearances between the cooling fins or tubes of the coolers 43 are made relatively large in order that these clearances are not clogged by foreign matters.

In the embodiment shown in Fig. 6, coolers 53 are disposed to the car body front and rear walls. In the pipes 24 between the coolers 53 and the transformer 21, change-over valves 54 are disposed for switching these change-over valves 54 in accordance with the running direction of the electric car so that the front cooler 53 in relation to the direction of travel of the vehicle is connected to the transformer 21 to circulate the refrigerant therethrough. The front cooler 53 is exposed to a large amount of running wind 41 and an effective cooling can be achieved, so that the cooler 53 can be small. The air flow that passed through the cooler 53 is guided as shown by an arrow 42 by an exhaust duct 55 to be discharged below the car body floor 2.

In the embodiment illustrated in Fig. 7, coolers 63 are embedded in their major portions in the car body side walls 3a and contained within a running wind duct 65 having an air intake 64 open toward the front side on the car body side walls 3a. The coolers 63 are arranged in a staggered relationship to improve the cooling efficiency. In this embodiment, the height of projection of the coolers 63

from the car body side walls 3a is relatively small, which is advantageous from the design view point.

The example shown in Fig. 8 utilizes a heat exchanger 74 having a heat pipe 73 as a cooler. More particularly, the heat exchanger 74 is connected to the pipe 24 under the floor 2 extended from the circulating pump 22, and a plurality of heat pipes 73 extend from the heat exchanger 74 upwardly along the car body side wall 3a. The refrigerant in the pipe 24 is cooled through the heat exchanger 74 and the heat pipe 73 by the running wind 41 flowing along the car body side wall 3a. In this embodiment, the external coolers to be exposed to the running wind on the car body side walls 3a can be made extremely compact.

Fig. 9 illustrates detailed structure of the transformer 21 and the circulating blower 22. The transformer 21 comprises a tank 21a, an iron core 21b contained in the tank 21a and a coil 21c wound around the iron core 21b. The circulating blower 22 is disposed within the tank 21a, and the discharge duct 22a of the blower 22 is connected to the pipe 24, so that, when the blower 22 is driven, the refrigerant gas circulates between the transformer 21 and the coolers 23 and the like while cooling the transformer 21. The circulating blower 22 is mounted by mounting brackets 27 attached to support beds 26 secured to the bottom of the tank 21a and vibration dumping means which is a vibration dumping material 28 such as a suitable rubber is interposed therebetween so that the vibration of the blower 22 is prevented to transmit to the tank 21a and generate noise. By placing the circulating blower 22 within the tank 21a through the vibration dumping means, the noise generated from the blower 22 can be prevented from leaking to the exterior of the tank 21a.

In the embodiment illustrated in Figs. 10 and 11, only fan 45a together with the blower casing of the circulating blower 45 is positioned within the tank 21a and the motor 45b is disposed outside of the tank 21a. The motor 45b is mounted to the tank 21a through a hermetically sealing and vibration dumping material 45c. With this arrangement, the fan 45a which is the main source of noise of the circulating blower 45 is contained within the tank 21a, so that the noise level is low, and since the motor 45b is outside of the tank 21a and easily removed, the assembly and maintenance of the blower 45 is easy.

Fig. 12 schematically illustrates the junction portion 31 which is inserted into the pipe 24 and which makes the manufacture, shipping, assembly, maintenance and inspection of the pipes and the transformer 21 easily carried out. More particularly, switch valves 31a and 31b which can be operated from the outside and which can seal the refrigerant gas are disposed at both ends of first and second

gas pipes 24a and 24b and a flexible connection pipe 31c is connected between both ends.

When it is desired to manufacture in the shop the cooling system for the electric car mounting transformer of the present invention, to ship to the site and to mount on an electric car, the cooling system must be disassembled into the transformer 21, the gas pipes 24 and the gas coolers 23 and the transformer 21 and the coolers 23 must be filled with an SF<sub>6</sub> gas at a prescribed pressure. For this purpose, the switch valves 31a and 31b at each end of the pipes 24a attached to the transformer 21 and the coolers 23 are sealingly closed and the refrigerant gas is filled therein, whereby the disassembled components can be shipped to the site. At the assembly site, the transformer 21 is mounted to the floor 2, the coolers 23 are mounted to the car body walls 3 and the pipes 24 are connected between these components. The dimensional errors sometimes occur between each pipe 24 during manufacture and installation, so that the pipes 24 are sealingly connected by the flexible connection pipe 31c through the use of usual flange, packings, bolts and nuts. Then, all the switch valves 31a and 31b and the like can be opened to make communication through the transformer 21, the coolers 23 the pipes 24 and the flexible connection pipe 31c to complete the gas refrigerant circuit for circulating the gas refrigerant throughout the cooling circuit.

Thus, by providing the connection portions 31 that can be opened and closed in the pipes 24, the need to achieve the gas refrigerant filling operation at the site such as vehicle assembling shop is eliminated and the installation can be made easy. Also, by closing the switch valves 31c of the connection portion 31 upon the disassembly or the inspection of the cooling system, the leakage of the gas refrigerant can be minimized.

#### ADVANTAGEOUS RESULTS OF THE INVENTION

As has been described, according to the cooling system for an electric car mounting transformer of the present invention, the refrigerant for the transformer is SF<sub>6</sub> gas, so that the transformer and the cooling system are incombustible, and the coolers are mounted to the car body walls, so that the installation space available for the equipments to be installed on the car floor can be increased. Also, since the system is light-weight and incombustible and the limitation of the length of the pipes is moderated and the degree of freedom of the cooler installation is increased, the coolers can be positioned in a more advantageous position. For example, the coolers may be disposed within a cooling duct for another electric apparatus to commonly use the cooling fan, or the electric car

running wind may be utilized to eliminate the need for the cooling fan. When no fan is used for the cooler, it is advantageous from the stand point of space, cost, weight and the like and the electric car can be made low-noise. By containing the circulating blower for the gas refrigerant within the transformer tank, the noise reduction can be further progressed. Further, by providing the connection portions in the pipes, the need for the refrigerant gas to be filled at site is eliminated, and the manufacture, the shipping, the assembly, the maintenance and inspection of the cooling system can be made easy.

#### **Claims**

1. A cooling system for an electric car mounting transformer comprising a refrigerant for cooling a transformer mounted on an electric car having a floor and car body walls disposed on the floor, a cooler for cooling said refrigerant, pipes connected between said transformer and said cooler and a circulating blower disposed in said pipe for circulating said refrigerant through said pipes between said transformer and said cooler, characterized in that said refrigerant is an SF<sub>6</sub> gas and said cooler is disposed to said car body wall of said electric car.
2. A cooling system as claimed in claim 1, wherein said cooler is disposed within a ventilation opening formed in the car body wall of said electric car and is cooled by an air flow flowing through said car body wall.
3. A cooling system as claimed in claim 2, wherein said cooler is disposed within the thickness dimension of said car body wall.
4. A cooling system as claimed in claim 2, further comprising a fan for generating said air flow.
5. A cooling system as claimed in claim 4, wherein said fan is a cooling fan commonly used for another equipment of the electric car.
6. A cooling system as claimed in claim 1, further comprising running wind intake means for generating said air flow.
7. A cooling system as claimed in claim 1, wherein said cooler is disposed on the car body side wall of said electric car.
8. A cooling system as claimed in claim 7, wherein said cooler is disposed within a ventilation opening formed in the car body side

wall of said electric car and is cooled by an air flow flowing through said car body side wall.

9. A cooling system as claimed in claim 7, further comprising a running wind duct having an air intake open toward the running direction of said electric car for guiding the running wind to said cooler to generate the air flow flowing through said cooler. 5
10. A cooling system as claimed in claim 1, wherein said cooler is disposed on said car body top wall of said electric car. 10
11. A cooling system as claimed in claim 10, wherein said cooler at least partly projects from the car body top wall of said electric car to be exposed to the air flow generated by the running of the electric car. 15
12. A cooling system as claimed in claim 1, wherein said cooler is disposed on car body front and rear end walls of said electric car. 20
13. A cooling system as claimed in claim 1, wherein said cooler is a heat pipe connected to said pipe through a heat exchanger. 25
14. A cooling system as claimed in claim 1, wherein said transformer includes a tank enclosing said transformer and containing said refrigerant, and said circulating blower is disposed within said tank. 30
15. A cooling system as claimed in claim 14, wherein said circulating blower is mounted within said tank through vibration dumping means. 35
16. A cooling system as claimed in claim 14, wherein said circulating blower includes a fan and an electric motor for driving the fan, and said fan only is disposed within said tank. 40
17. A cooling system as claimed in claim 1, wherein said pipe between said transformer and said cooler has a connection portion with a valve capable of opening and closing. 45

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FIG. 1

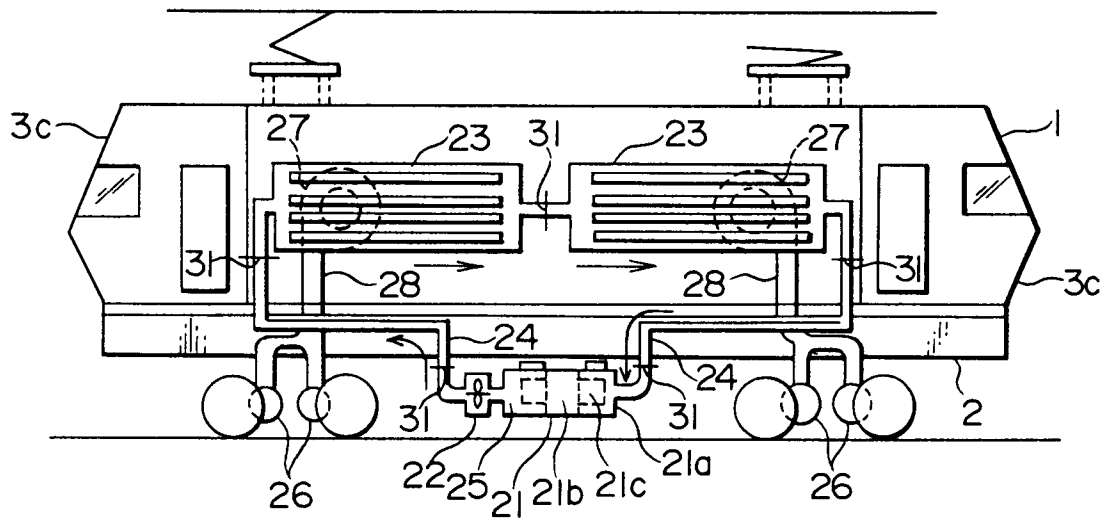


FIG. 2

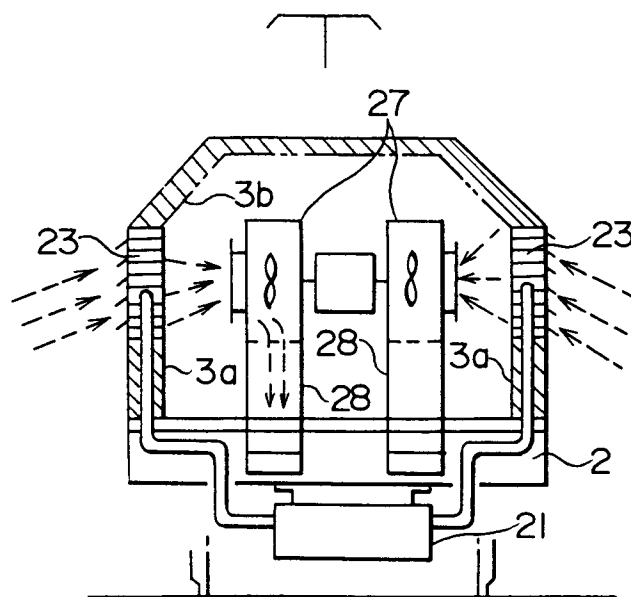




FIG. 3

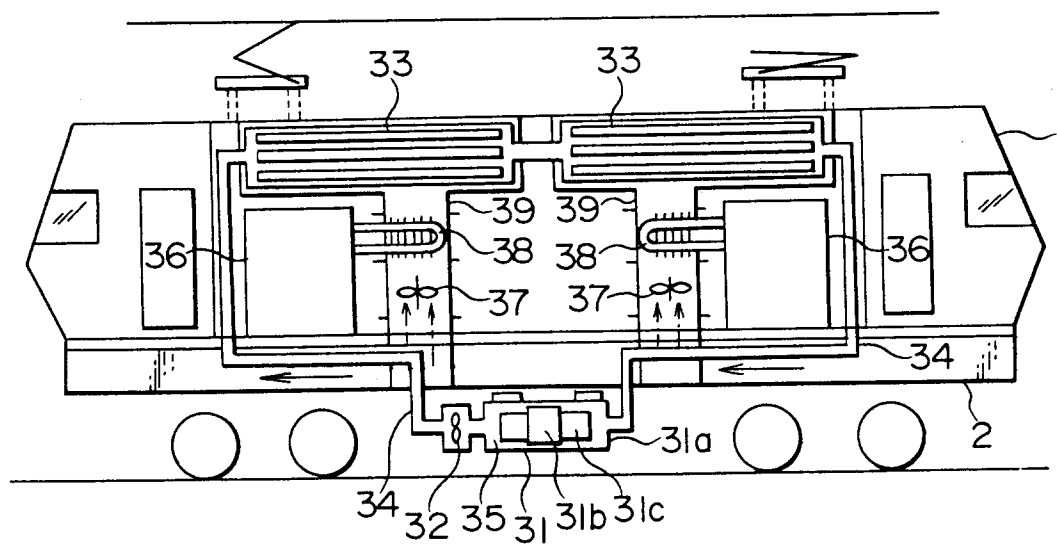


FIG. 4

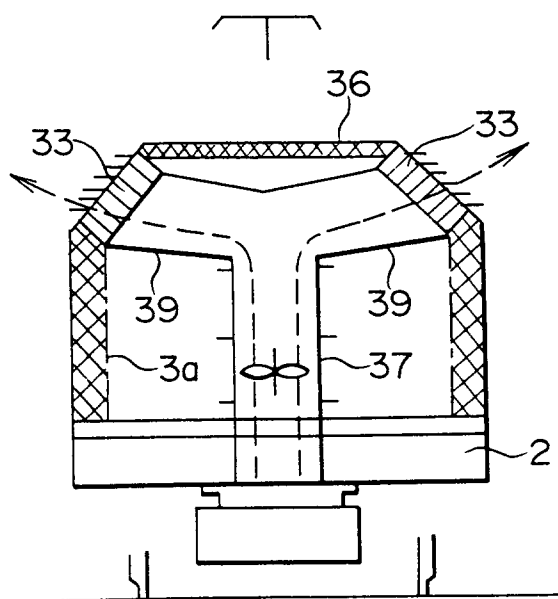
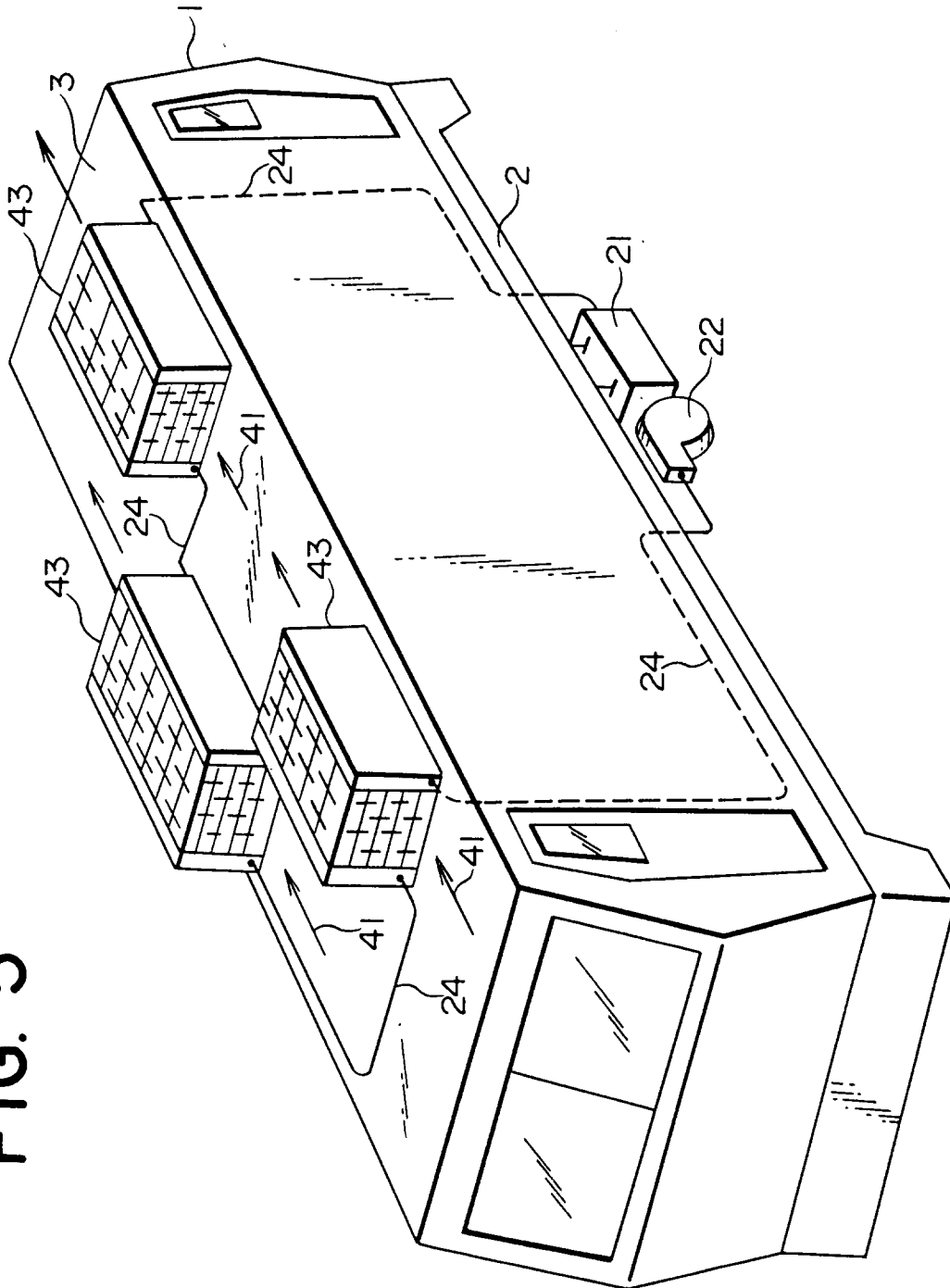


FIG. 5



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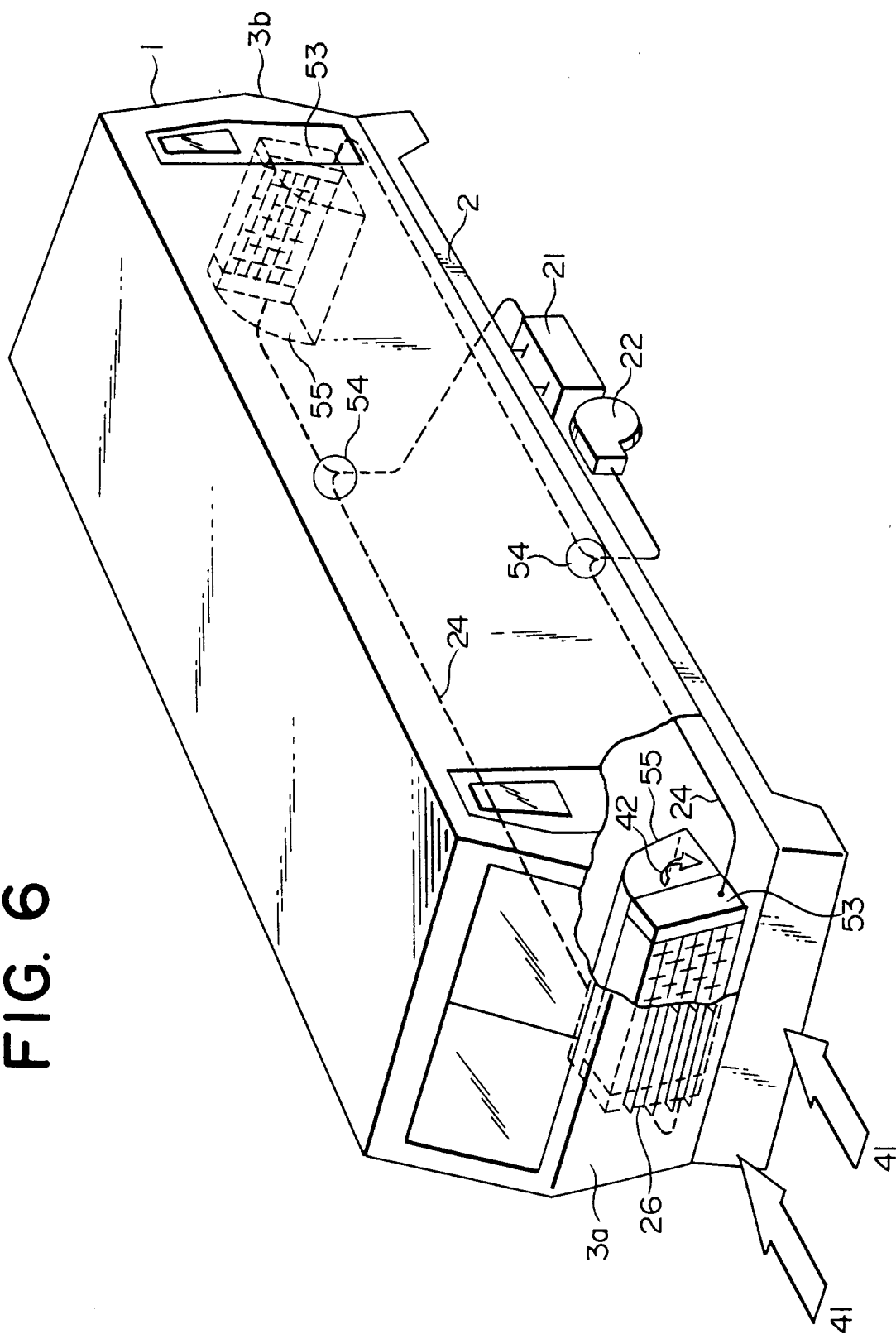


FIG. 7

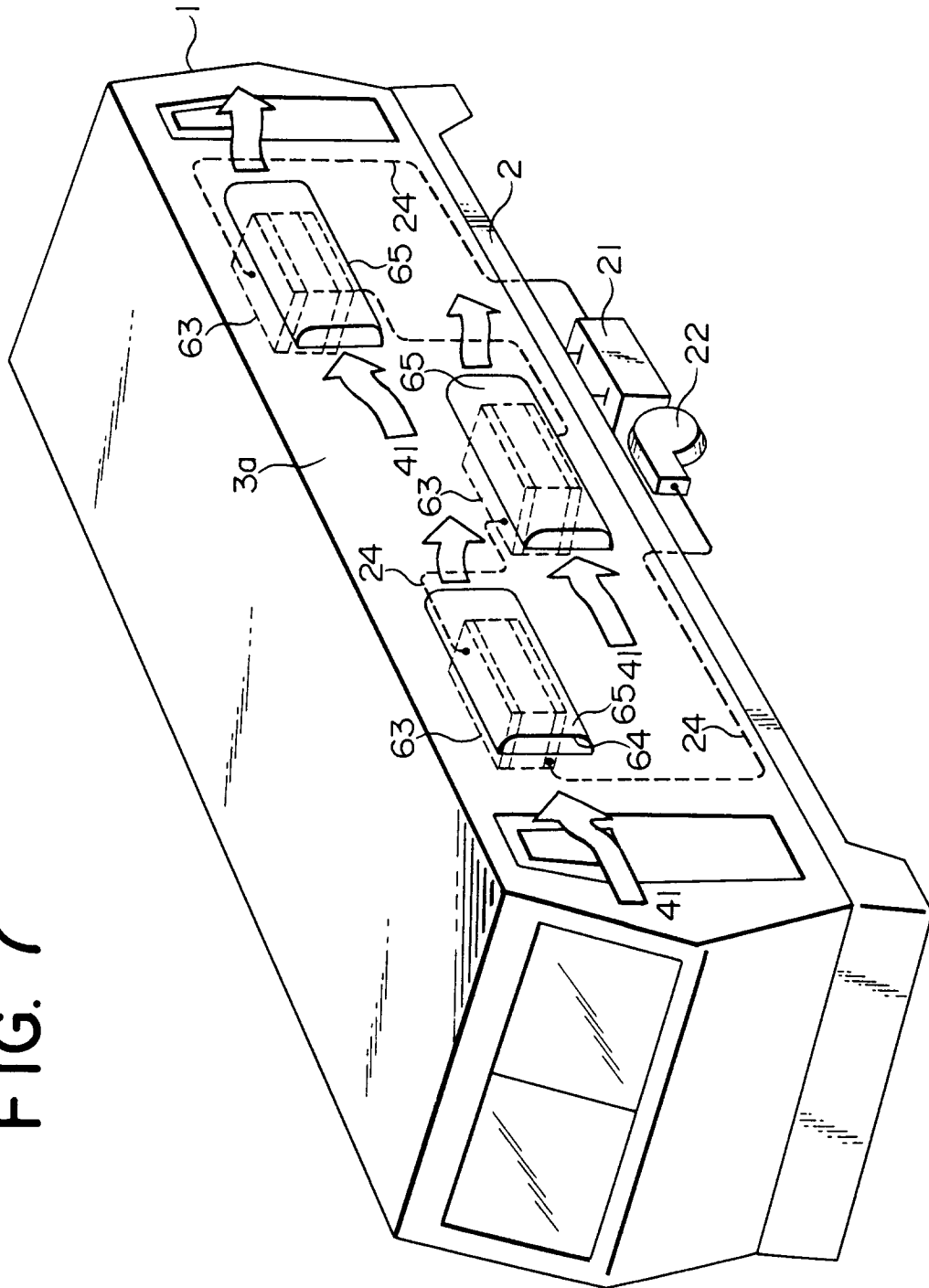


FIG. 8

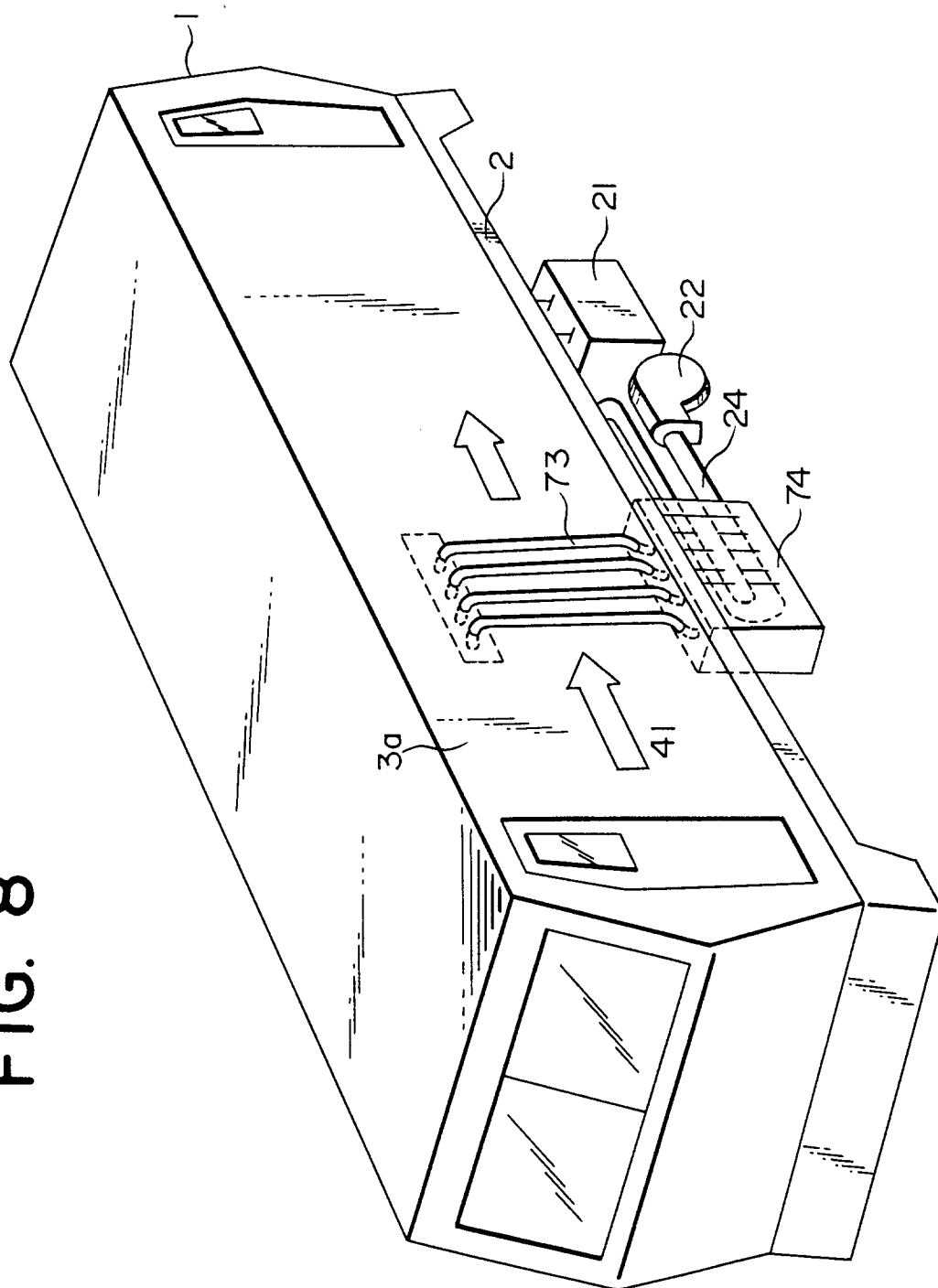


FIG. 9

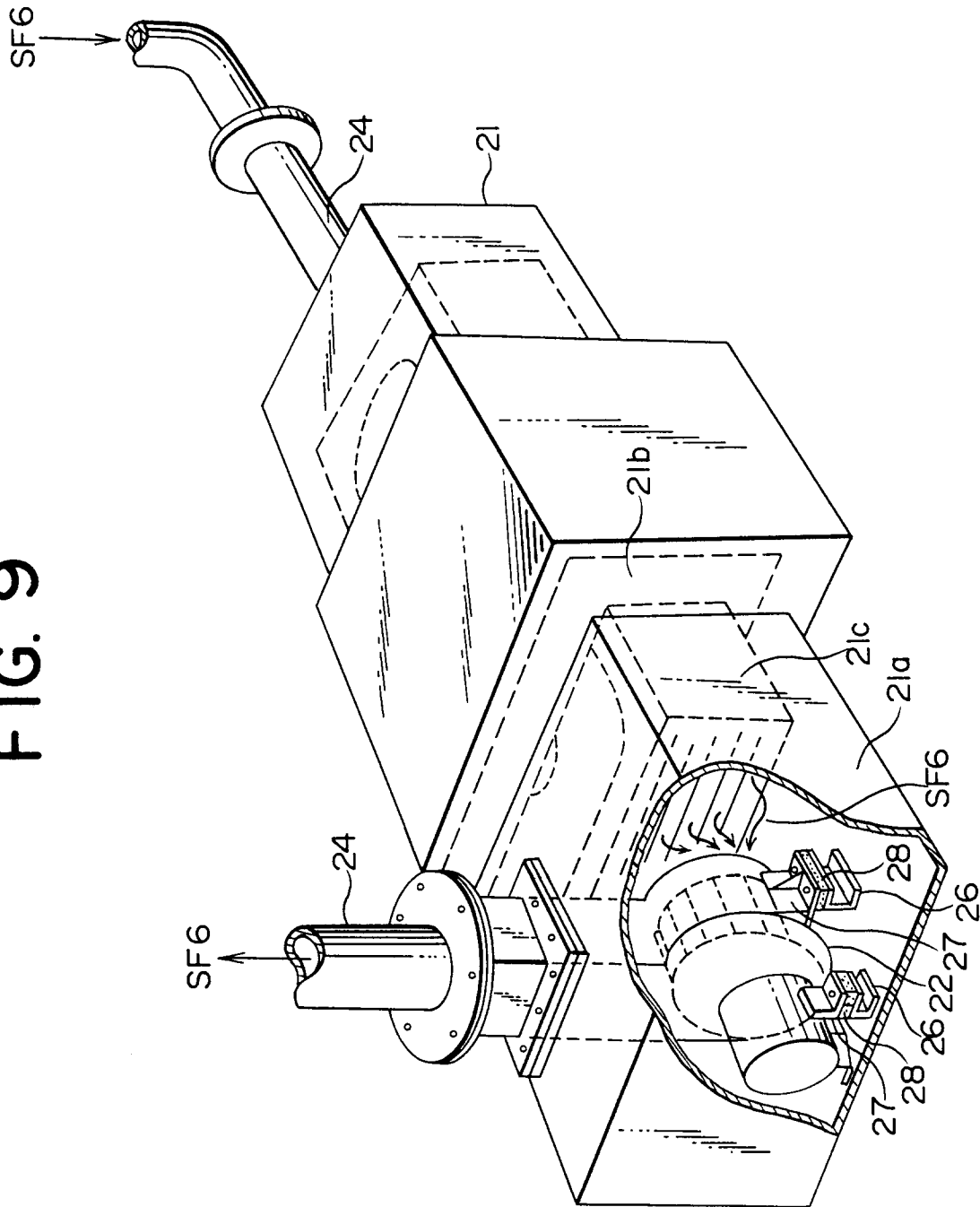


FIG. 10

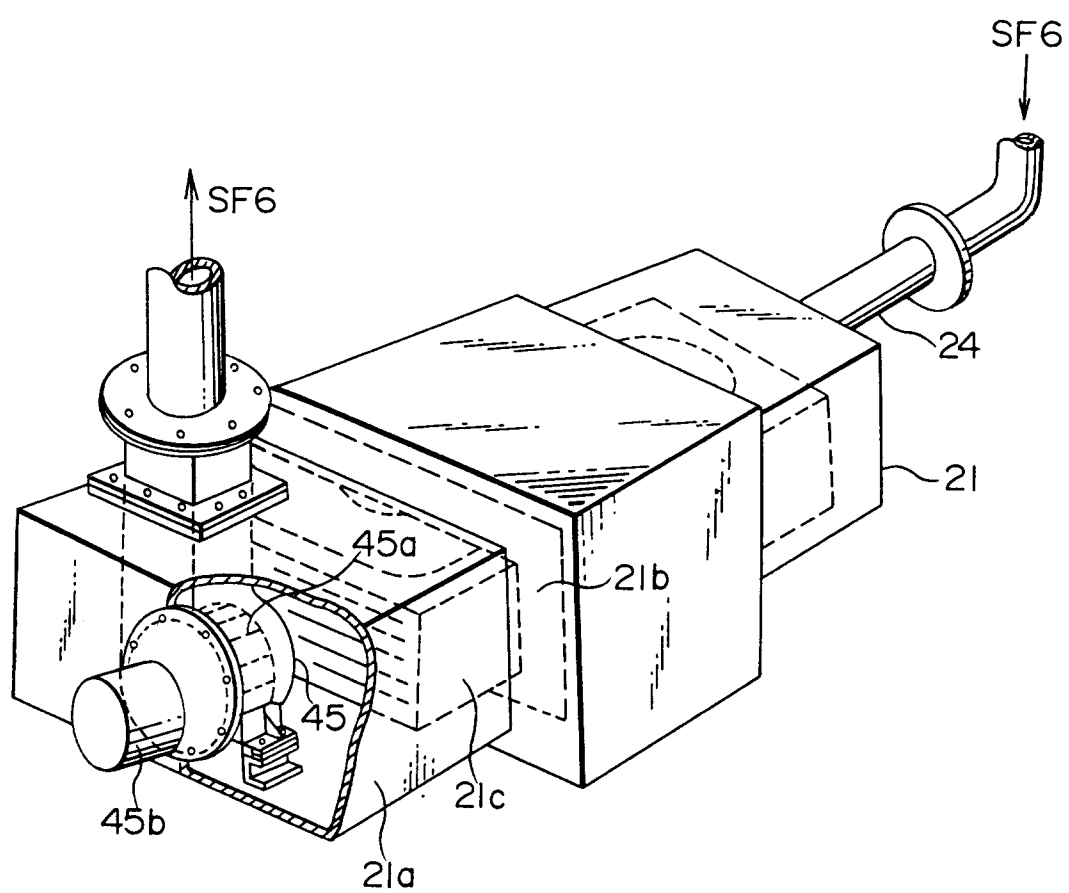


FIG. 11

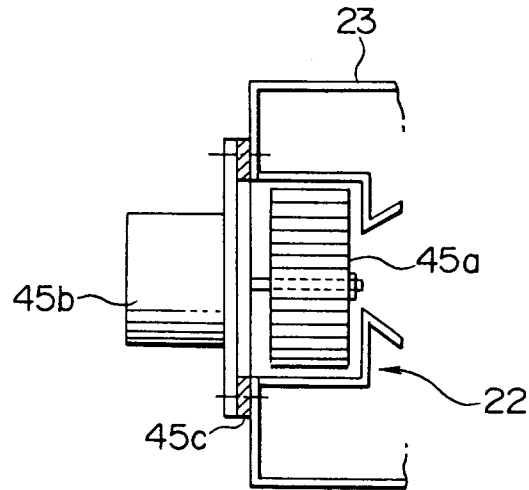


FIG. 12

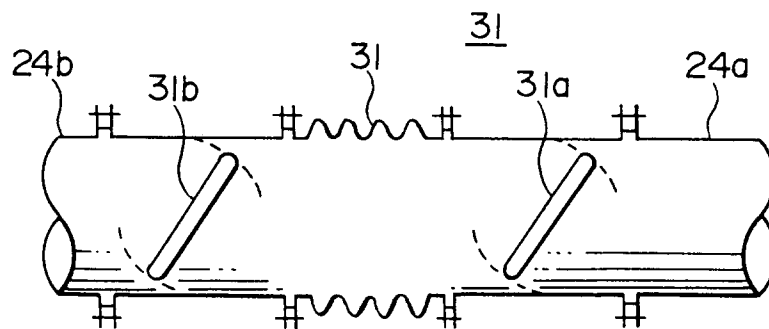




FIG. 13

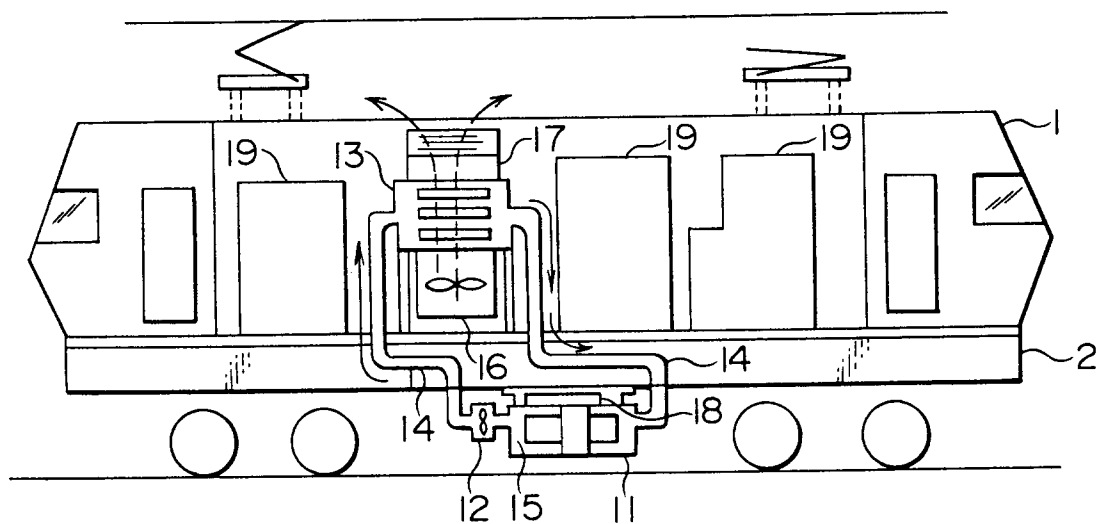
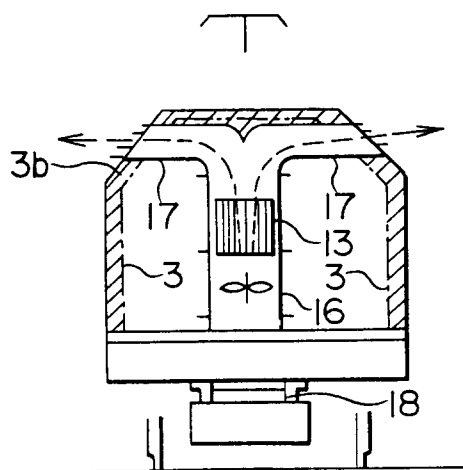


FIG. 14





European Patent  
Office

## EUROPEAN SEARCH REPORT

Application Number

EP 92 10 7433

### DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	IEEE TRANSACTIONS ON POWER APPARATUS AND SYSTEMS PAS-101 no. 2, 6 July 1982, NEW-YORK pages 2229 - 2235 SATO ET AL. 'cooling effect by gas density of sf6 gas insulated transformer' ---	1,4,14, 16	B61C3/00 B61C17/00 H01F27/20
A	PATENT ABSTRACTS OF JAPAN vol. 7, no. 123 (E-178)(1268) 27 May 1983 & JP-A-58 042 210 ( MITSUBISHI DENKI K.K. ) 11 March 1983 * abstract *	1,4,14, 16	
A	FR-A-1 146 044 (CIE FRANCAISE THOMSON-HOUSTON) * the whole document *	1,4,14, 16	
A	US-A-4 241 666 (MARCUSSON) * the whole document *	1,2,4-9, 12,16	
A	EP-A-0 082 360 (MITSUBISHI DENKI K. K.) * abstract; figures 1-8 *	14-16	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	US-A-2 638 056 (HEIDMANN) * the whole document *	1,10	B61C H01F
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 23 APRIL 1993	Examiner SCHMAL R.
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ----- & : member of the same patent family, corresponding document	