



(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 153(4) EPC

(43) Date of publication:
16.09.2020 Bulletin 2020/38

(21) Application number: **17930930.7**

(22) Date of filing: **06.11.2017**

(51) Int Cl.:
H01F 27/04 ^(2006.01) **H01F 27/02** ^(2006.01)
H01F 27/12 ^(2006.01) **H01F 27/08** ^(2006.01)
H01F 27/245 ^(2006.01) **H01F 30/10** ^(2006.01)

(86) International application number:
PCT/JP2017/039935

(87) International publication number:
WO 2019/087394 (09.05.2019 Gazette 2019/19)

(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 MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD

(71) Applicant: **Mitsubishi Electric Corporation**
Chiyoda-ku
Tokyo 100-8310 (JP)

(72) Inventor: **NODA, Toshihiro**
Tokyo 100-8310 (JP)

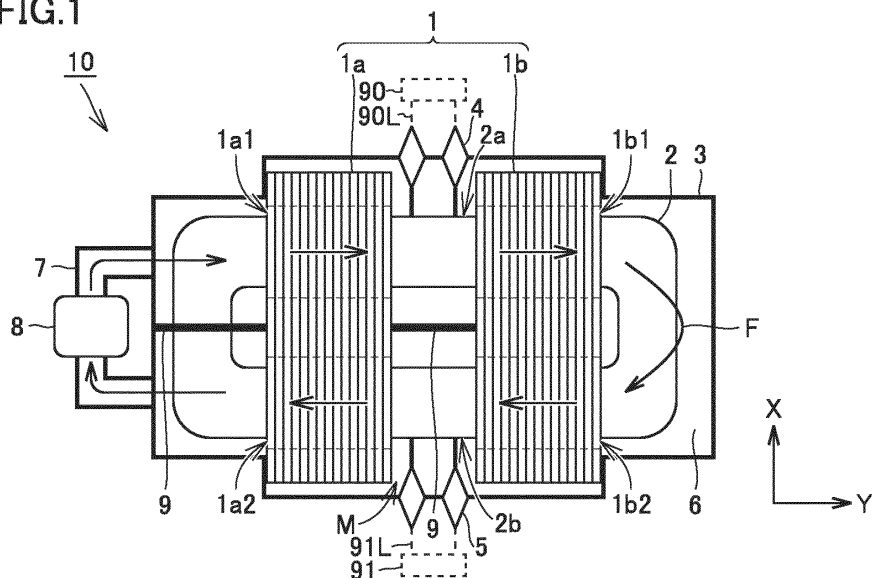
(74) Representative: **Witte, Weller & Partner**
Patentanwälte mbB
Postfach 10 54 62
70047 Stuttgart (DE)

(54) **STATIONARY INDUCTION MACHINE**

(57) An iron core (1) includes a first iron core portion (1a) and a second iron core portion (1b) located with a space (M) being interposed therebetween. Each of the first iron core portion (1a) and the second iron core portion (1b) has a first window portion (1a1, 1b1) and a second window portion (1a2, 1b2) through each of which a winding (2) extends. The first window portion (1a1) of the first iron core portion (1a) and the first window portion (1b1)

of the second iron core portion (1b) face each other. The second window portion (1a2) of the first iron core portion (1a) and the second window portion (1b2) of the second iron core portion (1b) face each other. A bushing (4, 5) is connected to the winding (2) via a space (M), and is provided at a position facing a portion (2a, 2b) of the winding (2) located in the space (M) in a tank (3).

FIG.1



Description

TECHNICAL FIELD

[0001] The present invention relates to a stationary induction device, particularly, a stationary induction device attachable to a vehicle.

BACKGROUND ART

[0002] WO 2008/007513 (Patent Literature 1) is a prior art document that discloses a configuration of a transformer for vehicles. The transformer for vehicles as described in Patent Literature 1 includes: an iron core; a winding; a tank filled with refrigerant; a pump that forcibly circulates the refrigerant; and a bushing attached to the tank. The bushing is provided at an end portion of the tank in a length direction of the tank that is orthogonal to each of a traveling direction of a vehicle and a center axis direction of the winding. The bushing is connected to an external device.

CITATION LIST

PATENT LITERATURE

[0003] PTL 1: WO 2008/007513

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0004] In the configuration in which the bushing is provided at the end portion of the tank in the length direction of the tank, when the external device to which the bushing is connected is disposed at a position close to a central portion of the tank in the length direction of the tank, routing of a connection wiring between the bushing and the external device becomes long and complicated.

[0005] The present invention has been made in view of the above-described problem, and has an object to provide a stationary induction device, by which routing of a connection wiring between a bushing and an external device to which the bushing is connected can be short and simplified when the external device is disposed at a position close to a central portion of a tank in a length direction of the tank.

SOLUTION TO PROBLEM

[0006] A stationary induction device according to the present invention includes an iron core, a winding, a tank, a pump, and a bushing. The winding is wound around the iron core. The tank stores the iron core and the winding. The tank is filled with refrigerant. The pump forcibly circulates the refrigerant. The bushing is electrically connected to the winding, and extends through the tank. The iron core includes a first iron core portion and a second

iron core portion located with a space being interposed between the first iron core portion and the second iron core portion. Each of the first iron core portion and the second iron core portion has a first window portion and a second window portion through each of which the winding extends. The first window portion of the first iron core portion and the first window portion of the second iron core portion face each other. The second window portion of the first iron core portion and the second window portion of the second iron core portion face each other. By driving the pump, the refrigerant is circulated by passing through the first window portion and the second window portion of each of the first iron core portion and the second iron core portion. The bushing is connected to the winding via the space, and is provided at a position facing a portion of the winding located in the space in the tank.

ADVANTAGEOUS EFFECTS OF INVENTION

[0007] According to the present invention, since the bushing is provided at the position of the tank corresponding to the space between one side and the other side of the divided iron core when the external device to which the bushing is connected is disposed at the position close to the central portion of the tank in the length direction of the tank, routing of a connection wiring between the bushing and the external device can be short and simplified.

BRIEF DESCRIPTION OF DRAWINGS

[0008]

Fig. 1 is a cross sectional view showing a configuration of a stationary induction device according to a first embodiment of the present invention.

Fig. 2 is a cross sectional view showing a configuration of a stationary induction device according to a second embodiment of the present invention.

DESCRIPTION OF EMBODIMENTS

[0009] The following describes a stationary induction device according to each of embodiments of the present invention with reference to figures. In the description of the embodiments below, the same or corresponding portions in the figures are given the same reference characters and are not described repeatedly. It should be noted that in each embodiment, a shell-type transformer serving as the stationary induction device will be described; however, the stationary induction device is not limited to the shell-type transformer, and may be a reactor or the like. Moreover, a stationary induction device attachable to a vehicle will be described; however, the stationary induction device does not necessarily need to be attached to a vehicle, and may be attached to a different structure.

First Embodiment.

[0010] Fig. 1 is a cross sectional view showing a configuration of a stationary induction device according to a first embodiment of the present invention. Fig. 1 shows a cross sectional view when a ground side is seen from a floor surface of a vehicle. Moreover, the X axis direction represents a traveling direction of the vehicle, and the Y axis direction represents a length direction of a tank orthogonal to each of the traveling direction of the vehicle and a center axis direction of a winding.

[0011] The stationary induction device according to the first embodiment of the present invention is mounted on a railroad vehicle and is attached under a floor of the vehicle. As shown in Fig. 1, a stationary induction device 10 according to the first embodiment of the present invention includes an iron core 1, a winding 2, a tank 3, a pump 8, and bushings.

[0012] Iron core 1 is a three-leg core in which thin steel plates are layered, and includes a main leg portion around which winding 2 is wound. Iron core 1 includes a first iron core portion 1a and a second iron core portion 1b located with a space M being interposed therebetween. First iron core portion 1a and second iron core portion 1b are arranged side by side in the length direction (Y axis direction) of tank 3.

[0013] First iron core portion 1a has a first window portion 1a1 and a second window portion 1a2 through each of which winding 2 extends. Second iron core portion 1b has a first window portion 1b1 and a second window portion 1b2 through each of which winding 2 extends. First window portion 1a1 of first iron core portion 1a and first window portion 1b1 of second iron core portion 1b face each other. Second window portion 1a2 of first iron core portion 1a and second window portion 1b2 of second iron core portion 1b face each other.

[0014] Winding 2 includes a primary winding at a high-voltage side, and a secondary winding at a low-voltage side. Winding 2 is formed by layering a plurality of disc-like windings each formed by winding a straight-angle electric wire in the form of a disc. The straight-angle electric wire includes: an electric wire portion having a cross section with a substantially rectangular shape; and an insulation coating portion that coats the electric wire portion.

[0015] Tank 3 stores iron core 1 and winding 2. Tank 3 is filled with refrigerant 6. Insulation oil or insulation gas can be used as refrigerant 6. Examples of the insulation oil usable herein include mineral oil, ester oil, silicone oil, or the like. Examples of the insulation gas usable herein include SF₆ gas, dried air, or the like. In the present embodiment, iron core 1 and winding 2 are immersed in the insulation oil.

[0016] A refrigerant pipe 7 for which a pump 8 is installed is connected to tank 3 at a wall portion located at one end of tank 3 in the length direction (Y axis direction) of tank 3. Tank 3 is provided with a partition member 9 that divides one end side of the inside of tank 3 in the length direction (Y axis direction) of tank 3 into two, i.e.,

one end side and the other end side in the traveling direction (X axis direction) of the vehicle.

[0017] In the length direction (Y axis direction) of tank 3, partition member 9 includes: a portion provided to be interposed between the main leg portion of first iron core portion 1a and the wall portion of tank 3 located at the one end of tank 3 in the length direction (Y axis direction) of tank 3; and a portion provided to be interposed between the main leg portion of first iron core portion 1a and the main leg portion of second iron core portion 1b.

[0018] Pump 8 forcibly circulates refrigerant 6. In the present embodiment, pump 8 is installed for refrigerant pipe 7. By driving pump 8, refrigerant 6 is circulated as indicated by an arrow F in Fig. 1 in the following manner: refrigerant 6 is sent out from pump 8, passes through first window portion 1a1 of first iron core portion 1a, first window portion 1b1 of second iron core portion 1b, second window portion 1b2 of second iron core portion 1b, and second window portion 1a2 of first iron core portion 1a, and returns to pump 8. It should be noted that the circulation direction of refrigerant 6 may be a direction opposite to the direction indicated by arrow F.

[0019] The bushings are electrically connected to winding 2, and extend through tank 3. The bushings include: a first bushing 4 electrically connected to the primary winding; and a second bushing 5 electrically connected to the secondary winding.

[0020] First bushing 4 is connected to winding 2 via space M between first iron core portion 1a and second iron core portion 1b, and is provided at a position facing a portion 2a of winding 2 located in space M between first iron core portion 1a and second iron core portion 1b in tank 3. That is, first bushing 4 is provided at a position of tank 3 corresponding to space M between first iron core portion 1a and second iron core portion 1b. By way of a connection wiring 90L, first bushing 4 is electrically connected to an external device 90 disposed at a position close to the central portion of tank 3 in the length direction (Y axis direction) of tank 3.

[0021] Second bushing 5 is connected to winding 2 via space M between first iron core portion 1a and second iron core portion 1b, and is provided at a position facing a portion 2b of winding 2 located in space M between first iron core portion 1a and second iron core portion 1b in tank 3. That is, second bushing 5 is provided at a position of tank 3 corresponding to space M between first iron core portion 1a and second iron core portion 1b. By way of a connection wiring 91L, second bushing 5 is electrically connected to an external device 91 disposed at a position close to the central portion of tank 3 in the length direction (Y axis direction) of tank 3.

[0022] It should be noted that the main body of each of external device 90 and external device 91 does not necessarily need to be disposed at the position close to the central portion of tank 3 in the length direction (Y axis direction) of tank 3, and a connection terminal of each of the respective external devices connected to the bushings may be disposed at the position close to the central

portion of tank 3 in the length direction (Y axis direction) of tank 3. Examples of external device 90 include a pantograph connected to an overhead wire, and the like. Examples of external device 91 include circuit devices, such as an inverter and a converter, which are connected to a motor or an air conditioning facility.

[0023] In stationary induction device 10 according to the first embodiment of the present invention, since first bushing 4 is provided at the position of tank 3 corresponding to space M between first iron core portion 1a and second iron core portion 1b, routing of connection wiring 90L that connects first bushing 4 and external device 90 to each other can be short and simplified. Likewise, since second bushing 5 is provided at the position of tank 3 corresponding to space M between first iron core portion 1a and second iron core portion 1b, routing of connection wiring 91L that connects second bushing 5 and external device 91 to each other can be short and simplified.

[0024] It should be noted that at least one of first bushing 4 and second bushing 5 may be provided at the position of tank 3 corresponding to space M between first iron core portion 1a and second iron core portion 1b. Specifically, at least one of the following conditions may be satisfied: first bushing 4 is provided at the position facing portion 2a of winding 2 located in space M between first iron core portion 1a and second iron core portion 1b in tank 3; and second bushing 5 is provided at the position facing portion 2b of winding 2 located in space M between first iron core portion 1a and second iron core portion 1b in tank 3.

[0025] Since a bushing is provided at the position of tank 3 corresponding to space M between one side and the other side of divided iron core 1, the length of the wiring between winding 2 and the bushing can be short. Accordingly, weight saving of stationary induction device 10 can be attained.

Second Embodiment.

[0026] The following describes a stationary induction device according to a second embodiment of the present invention with reference to figures. It should be noted that since the stationary induction device according to the second embodiment is different from the stationary induction device according to the first embodiment mainly in the positioning of the pump, the same configuration as that of stationary induction device 10 according to the first embodiment will not be described repeatedly.

[0027] Fig. 2 is a cross sectional view showing the configuration of the stationary induction device according to the second embodiment of the present invention. Fig. 2 shows a cross sectional view when a ground side is seen from a floor surface of a vehicle. Moreover, the X axis direction represents a traveling direction of the vehicle, and the Y axis direction represents a length direction of a tank orthogonal to each of the traveling direction of the vehicle and a center axis direction of a winding.

[0028] As shown in Fig. 2, in stationary induction de-

vice 20 according to the second embodiment of the present invention, a pump 28 is disposed at a position internal to winding 2 in space M between first iron core portion 1a and second iron core portion 1b. In the present embodiment, pump 28 is an oil-immersed pump. Since pump 28 is disposed at the position internal to winding 2 in space M between first iron core portion 1a and second iron core portion 1b, no refrigerant pipe 7 and no partition member 9 are provided in tank 3.

[0029] By driving pump 28, refrigerant 6 is circulated as indicated by an arrow F1 and an arrow F2 in Fig. 1 in the following manner: refrigerant 6 is sent out from pump 28, passes through second window portion 1a2 of first iron core portion 1a or second window portion 1b2 of second iron core portion 1b and through first window portion 1a1 of first iron core portion 1a or first window portion 1b1 of second iron core portion 1b, and returns to pump 28. It should be noted that the circulation directions of refrigerant 6 may be directions opposite to the directions indicated by arrow F1 and arrow F2.

[0030] Also in stationary induction device 20 according to the second embodiment of the present invention, since first bushing 4 is provided at the position of tank 3 corresponding to space M between first iron core portion 1a and second iron core portion 1b, routing of connection wiring 90L that connects first bushing 4 and external device 90 to each other can be short and simplified. Likewise, since second bushing 5 is provided at the position of tank 3 corresponding to space M between first iron core portion 1a and second iron core portion 1b, routing of connection wiring 91L that connects second bushing 5 and external device 91 to each other can be short and simplified.

[0031] Further, since pump 28 is disposed at the position internal to winding 2 in space M between first iron core portion 1a and second iron core portion 1b, it becomes unnecessary to provide refrigerant pipe 7 and partition member 9, thereby attaining downsizing and weight saving of stationary induction device 20.

[0032] It should be noted that the above-described embodiments disclosed herein are illustrative in any respect and do not serve as grounds for restrictive interpretation. Therefore, the technical scope of the present invention is not interpreted only in view of the above-described embodiments, and is defined by the description of claims. Moreover, all the modifications equivalent to the claims in terms of meaning and scope are encompassed.

REFERENCE SIGNS LIST

[0033] 1: iron core; 1a: first iron core portion; 1a1, 1b1: first window portion; 1a2, 1b2: second window portion; 1b: second iron core portion; 2: winding; 2a, 2b: portion located in a space between the first iron core portion and the second iron core portion of the winding in the tank; 3: tank; 4: first bushing; 5: second bushing; 6: refrigerant; 7: refrigerant pipe; 8, 28: pump; 9: partition member; 10, 20: stationary induction device; 90, 91: external device;

90L, 91L: connection wiring.

Claims

5

1. A stationary induction device comprising:

an iron core;
 a winding wound around the iron core;
 a tank to store the iron core and the winding, the 10
 tank being filled with refrigerant;
 a pump to forcibly circulate the refrigerant; and
 a bushing electrically connected to the winding,
 the bushing extending through the tank, wherein
 the iron core includes a first iron core portion 15
 and a second iron core portion located with a
 space being interposed between the first iron
 core portion and the second iron core portion,
 each of the first iron core portion and the second
 iron core portion has a first window portion and 20
 a second window portion through each of which
 the winding extends,
 the first window portion of the first iron core por-
 tion and the first window portion of the second
 iron core portion face each other, 25
 the second window portion of the first iron core
 portion and the second window portion of the
 second iron core portion face each other,
 by driving the pump, the refrigerant is circulated
 by passing through the first window portion and 30
 the second window portion of each of the first
 iron core portion and the second iron core por-
 tion, and
 the bushing is connected to the winding via the
 space, and is provided at a position facing a por- 35
 tion of the winding located in the space in the
 tank.

2. The stationary induction device according to claim 40 1, wherein the pump is disposed at a position internal to the winding in the space.

45

50

55

FIG. 1

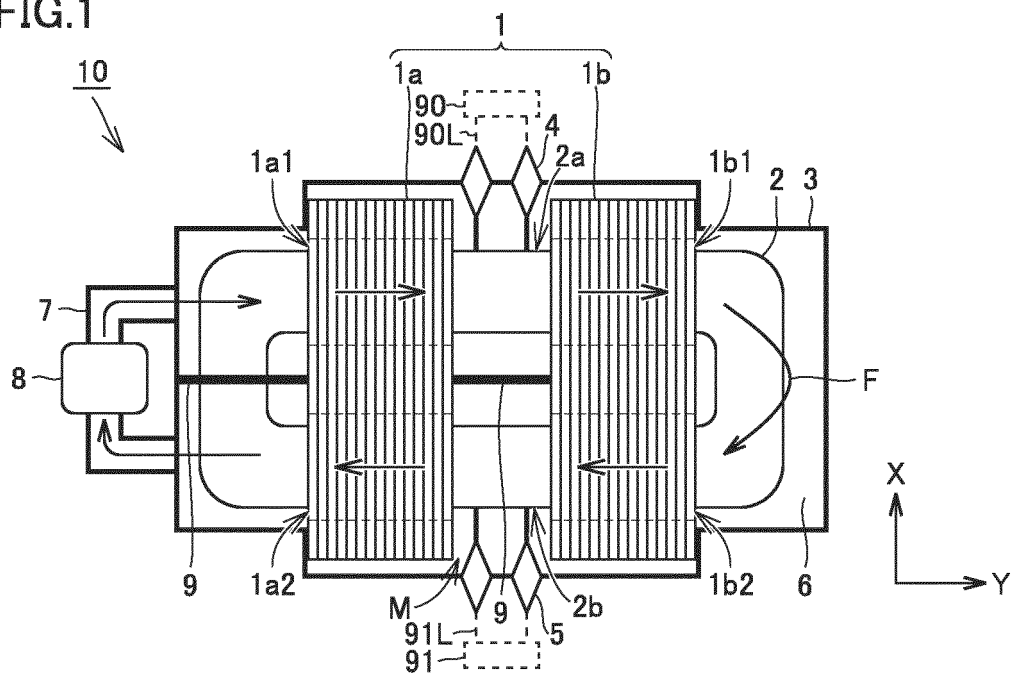
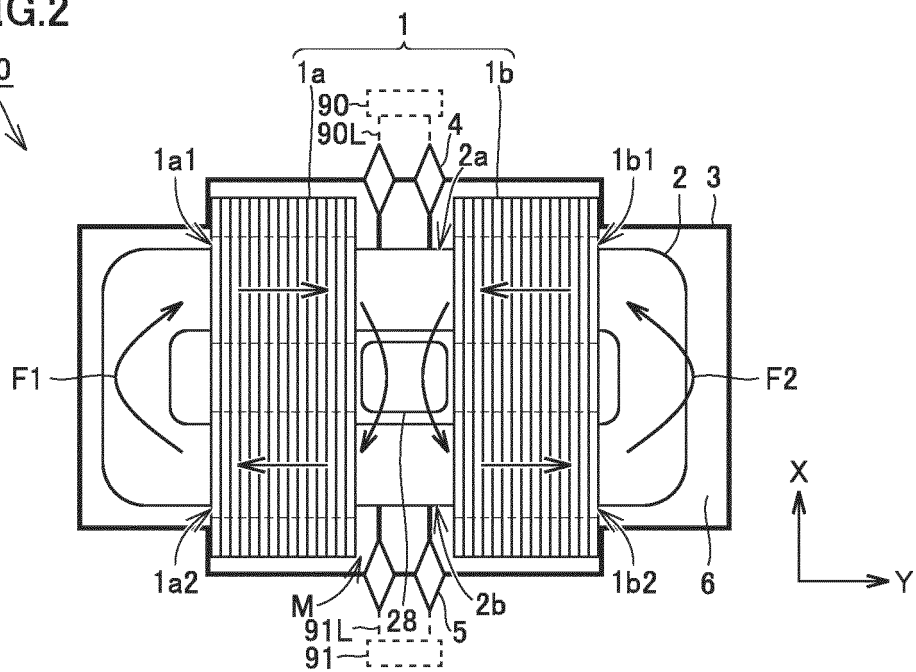


FIG.2



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2017/039935

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. H01F27/02 (2006.01) i, H01F27/04 (2006.01) i, H01F27/08 (2006.01) i,
H01F27/12 (2006.01) i

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)

Int. Cl. H01F27/02, H01F27/04, H01F27/08, H01F27/12, H01F27/24,
H01F29/02, H01F29/04, H01F30/10, H01F30/12, H01F37/00

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

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2018
Registered utility model specifications of Japan 1996-2018
Published registered utility model applications of Japan 1994-2018

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2008/007513 A1 (MITSUBISHI ELECTRIC CORP.) 17 January 2008, paragraphs [0010]-[0020], fig. 1-3 & US 2009/0261933 A1, paragraphs [0020]-[0038], fig. 1-3 & EP 2040273 A1 & CN 101473389 A	1-2
A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 026129/1981 (Laid-open No. 140720/1982) (TOHOKU METAL INDUSTRY CO., LTD.) 03 September 1982, page 2, line 18 to page 4, line 12, fig. 5, 6 (Family: none)	1-2
A	JP 41-21215 Y1 (KK OTAKE KENKYUSHO) 18 October 1966, entire text (Family: none)	1-2

☒ 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
05.01.2018

Date of mailing of the international search report
16.01.2018

Name and mailing address of the ISA/
Japan Patent Office
3-4-3, Kasumigaseki, Chiyoda-ku,
Tokyo 100-8915, Japan

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2017/039935

5	C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
	Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
10	A	JP 58-87807 A (TOKYO SHIBAURA ELECTRIC CO., LTD.) 25 May 1983, page 3, upper right column, line 20 to page 3, lower left column, line 14, fig. 9 (Family: none)	1-2
15 20	A	Microfilm of the specification and drawings annexed to the request of Japanese Utility Model Application No. 049464/1979 (Laid-open No. 149934/1980) (HITACHI, LTD.) 29 October 1980, page 4, line 17 to page 5, line 18, fig. 3 (Family: none)	1-2
25			
30			
35			
40			
45			
50			
55			

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- WO 2008007513 A [0002] [0003]