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

(11) **EP 4 456 107 A1**

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

(43) Date of publication:
30.10.2024 Bulletin 2024/44

(21) Application number: **21968890.0**

(22) Date of filing: **21.12.2021**

(51) International Patent Classification (IPC):
H01H 33/662 *(2006.01)* ***H01H 33/666*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
H01H 33/662; H01H 33/666

(86) International application number:
PCT/JP2021/047439

(87) International publication number:
WO 2023/119453 (29.06.2023 Gazette 2023/26)

(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:
KH MA MD TN

(71) Applicant: **Hitachi Industrial Equipment Systems Co., Ltd.**
Tokyo 101-0021 (JP)

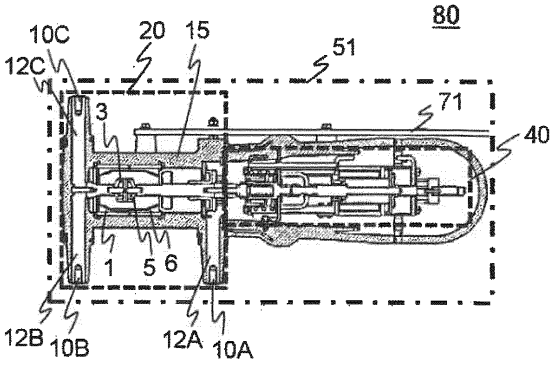
(72) Inventors:
- **TAMURA Kozo**
  Tokyo 101-0021 (JP)
- **KOBAYASHI Masato**
  Tokyo 101-0021 (JP)
- **SHIRAI Hiroyuki**
  Tokyo 101-0021 (JP)

(74) Representative: **MERH-IP Matias Erny Reichl Hoffmann**
Patentanwälte PartG mbB
Paul-Heyse-Strasse 29
80336 München (DE)

(54) **SWITCH**

(57) The purpose of the present invention is to provide a switch the size of which can be reduced. In order to achieve the purpose, this switch is configured to have: a main circuit section which is formed from a vacuum interrupter equipped with an opening/closing part formed from a stationary electrode and a movable electrode to be separated from or brought into contact with the stationary electrode, a first bushing conductor electrically connected to a stationary conductor connected to the stationary electrode and pulled out to the outside of the vacuum interrupter, and a second bushing conductor electrically connected to a movable conductor connected to the movable electrode and pulled out to the outside of the vacuum interrupter; and an operation unit which is directly connected to the movable conductor pulled out to the outside of the vacuum interrupter and carries out operation of the opening/closing part by moving the movable electrode, wherein the operation unit is integrally molded with the main circuit section by using a solid insulating member.

[FIG. 1]



EP 4 456 107 A1

Description

Technical Field

[0001] The present invention relates to a high-voltage switch molded from resin.

Background Art

[0002] A switch that handles a high voltage and includes a vacuum interrupter, a circuit breaker, a load switch, and the like is molded from resin in order to protect surroundings from a high electric field around a device and to improve insulation performance.

[0003] For example, PTL 1 is related art literature in the present technical field. PTL 1 discloses a vacuum switching device including a vacuum interrupter provided with a stationary electrode and a movable electrode to be separated from or brought into contact with the stationary electrode, and an insulating operation rod disposed coaxially with a movable conductor connected to the movable electrode, in which the vacuum interrupter and the insulating operation rod are molded using a solid insulator that covers surroundings of the vacuum interrupter and the insulating operation rod.

Citation List

Patent Literature

[0004] PTL 1: JP2019-32994A

Summary of Invention

Technical Problem

[0005] In PTL 1, the insulating operation rod is used to couple a main circuit part that is a high-potential switch part and a ground potential operation unit coupled to the insulating operation rod. In order to ensure sufficient insulation performance, it is required to increase a dimension of the insulating operation rod to ensure an insulation distance. Therefore, there is a problem that miniaturization cannot be achieved. In order to achieve miniaturization, it is possible to shorten the dimension of the insulating operation rod and ensure insulation performance by using a medium having a high insulation strength such as an insulating gas or evacuating a space of an insulating operation rod portion, but there is a problem that it is insufficient and expensive.

[0006] In view of the above problems, an object of the invention is to provide a switch that can be reduced in size.

Solution to Problem

[0007] According to an embodiment of the invention, a switch includes: a main circuit unit including a vacuum interrupter provided with an opening and closing part having a stationary electrode and a movable electrode to be separated from or brought into contact with the stationary electrode, a first bushing conductor electrically connected to a stationary conductor that is connected to the stationary electrode and is pulled out to the outside of the vacuum interrupter, and a second bushing conductor electrically connected to a movable conductor that is connected to the movable electrode and is pulled out to the outside of the vacuum interrupter; and an operation unit directly coupled to the movable conductor pulled out to the outside of the vacuum interrupter and configured to operate the opening and closing part by moving the movable electrode, in which the operation unit is integrally molded with the main circuit unit using a solid insulating member to form a mold.

Advantageous Effects of Invention

[0008] According to the invention, it is possible to provide a switch that can be reduced in size.

Brief Description of Drawings

[0009]

[FIG. 1] FIG. 1 is a cross-sectional view taken along a plane including a central axis of a vacuum interrupter according to an embodiment.
[FIG. 2] FIG. 2 is a functional configuration schematic diagram showing the vacuum interrupter according to the embodiment.
[FIG. 3] FIG. 3 is another functional configuration schematic diagram showing the vacuum interrupter according to the embodiment.
[FIG. 4] FIG. 4 is a cross-sectional view taken along a plane including a central axis of a vacuum interrupter in the related art.

Description of Embodiments

[0010] Hereinafter, embodiments of the invention will be described with reference to the drawings.

Embodiment

[0011] In the present embodiment, a vacuum interrupter for a railway vehicle will be described as an example of a switch. FIG. 4 is a cross-sectional view taken along a plane including a central axis of a vacuum interrupter in the related art serving as a premise of the invention.

[0012] For example, a railway vehicle is formed of a plurality of carriages, a high-voltage pull-through cable is disposed on a roof of each carriage, and the railway vehicle receives electric power from an electric wire via a pantograph connected to the high-voltage pull-through cable. The high-voltage pull-through cables of the carriages are connected between the carriages by straight

joints, and are branched toward carriage floors by T-branch joints. The T-branch joint and the straight joint constitute an integrated switch. The switch is mounted on a fixed portion of the railway vehicle.

[0013] In FIG. 4, a vacuum interrupter 70 has electrical connection portions 10A, 10B, and 10C, the electrical connection portions 10B and 10C are electrically connected inside the vacuum interrupter 70, and the electrical connection portions 10B and 10C constitute a T-branch joint. An opening and closing part including a stationary electrode and a movable electrode to be described later is provided between the electrical connection portions 10A and the electrical connection portions 10B and 10C inside the vacuum interrupter 70, and the electrical connection portion 10A and the electrical connection portions 10B and 10C constitute a straight joint. Although not shown, the vacuum interrupter 70 is used in a state where a T-shaped cable head is connected to the electrical connection portions 10A, 10B, and 10C. The vacuum interrupter 70 is mounted on a railway vehicle in a state where the vacuum interrupter 70 is fixed to a base 71 via a stay.

[0014] The vacuum interrupter 70 includes a vacuum interrupter 1 including a stationary electrode 3, a movable electrode 5 to be separated from or brought into contact with the stationary electrode 3, an arc shield 6 that covers surroundings of the stationary electrode 3 and the movable electrode 5, and the like. An inner side of an outer container of the vacuum interrupter 1 is maintained in a vacuum state. The vacuum interrupter 70 makes use of rapid diffusion of an arc into a vacuum, thereby extinguishing the arc in a vacuum container. Such a configuration is also used in a vacuum switch, and is used at voltages from a high voltage to an ultra-high voltage. Such a configuration is also used in a high-voltage switchboard or the like in view of durability and maintainability.

[0015] The stationary electrode 3 is connected to a stationary conductor, and the stationary conductor is pulled out to the outside of the vacuum interrupter 1 and electrically connected to bushing conductors 12B and 12C on a stationary conductor side. The movable electrode 5 is connected to a movable conductor, and the movable conductor is pulled out to the outside of the vacuum interrupter 1 and electrically.connected to a bushing conductor 12A on a movable conductor side.

[0016] Here, a high voltage of, for example, 25 KV to 30 KV is applied to the opening and closing part including the stationary electrode and the movable electrode. On the other hand, an operation unit 40 necessary for operating the opening and closing part including the stationary electrode and the movable electrode by moving the movable electrode is at a ground potential, and an electric circuit constituting the operation unit 40 is a low-voltage circuit of, for example, DC 100 V.

[0017] In order to insulate the opening and closing part of a high potential from the operation unit of a ground potential, an insulating operation rod 30 is provided of which one end is coupled to the movable conductor and the other end is coupled to the operation unit 40. The operation unit 40 operates the insulating operation rod 30 to operate the opening and closing part including the stationary electrode and the movable electrode by moving the movable electrode while maintaining a vacuum state of the vacuum interrupter 1. The operation unit 40 generates a drive force by, for example, combining a permanent magnet and an electromagnet with a spring and switching to turn on or turn off energization to a coil constituting the electromagnet.

[0018] An air insulating space 31 around the insulating operation rod 30 and a main circuit unit 20 including the vacuum interrupter 1, the bushing conductors 12B and 12C on the stationary conductor side, the bushing conductor 12A on the movable conductor side, and the like are integrally formed using a solid insulating member 15 made of thermosetting resin such as an epoxy resin in a manner of covering outer peripheral portions of the main circuit unit 20 and the air insulating space 31, thereby forming a mold insulator 50 indicated by a one-dot chain line.

[0019] As described above, the insulating operation rod is used to couple the main circuit unit of a high potential and the operation unit of a ground potential in the related art. Therefore, in order to ensure sufficient insulation performance, it is required to increase a dimension of the insulating operation rod to ensure an insulation distance. Therefore, there is a problem that miniaturization cannot be achieved. In order to achieve miniaturization, it is possible to shorten the dimension of the insulating operation rod and ensure insulation performance by using a medium having a high insulation strength such as an insulating gas or evacuating a space of an insulating operation rod portion, but there is a problem that it is insufficient and expensive.

[0020] Therefore, the operation unit and the main circuit unit are directly coupled and molded from resin in the present embodiment, so that the air insulating space 31 is not necessary and miniaturization is achieved. Hereinafter, the present embodiment will be described in detail.

[0021] FIG. 1 is a cross-sectional view taken along a plane including a central axis of a vacuum interrupter according to the present embodiment. In FIG. 1, the same components as those in FIG. 4 are denoted by the same reference numerals, and description thereof will be omitted. FIG. 1 is different from FIG. 4 in that the insulating operation rod 30 and the air insulating space 31 are not provided, and the operation unit 40 and the main circuit unit 20 are directly coupled and integrally molded as a whole using the solid insulating member 15 made of resin.

[0022] As shown in FIG. 1, in a vacuum interrupter 80 according to the present embodiment, the operation unit 40 is coupled to a movable conductor of the main circuit unit 20 pulled out to the outside of the vacuum interrupter 1, and the operation unit 40 is directly coupled to the main circuit unit 20. Accordingly, an insulation distance be-

tween the main circuit unit and the operation unit is not necessary, and the insulating operation rod 30 and the air insulating space 31 is not necessary, so that miniaturization can be achieved. The operation unit 40 becomes the same charging unit as the main circuit unit 20 by directly coupling the operation unit 40 to the main circuit unit 20. Accordingly, it is not a current path and thus no current flows through the path, but insulation is required. Therefore, the operation unit 40 and the main circuit unit 20 are molded as a whole to . form a mold insulator 51, and a surface of the mold insulator 51 is grounded.

[0023] Since the operation unit is operated by a low-voltage circuit, it is required to avoid contact with a high-voltage part of the main circuit unit. Therefore, a drive circuit, an auxiliary circuit, and other components are separated from the operation unit, and only a mechanical part is molded with the operation unit.

[0024] FIG. 2 is a functional configuration schematic diagram showing the vacuum interrupter according to the present embodiment. In FIG. 2, 'among a mechanical part 42, a drive source 43 such as an electromagnet including a drive coil, an auxiliary circuit 44 such as a proximity sensor or a magnetic sensor for monitoring a state of a contact point of the opening and closing part, and other component 45 such as an operation counter or a thermometer, which are components in an operation unit in the related art, components other than the mechanical part 42 are disposed outside the solid insulating member 15. Accordingly, even when the operation unit is operated by a low-voltage circuit, an electric circuit part can avoid contact with a high-voltage part of the main circuit unit outside a mold. In FIG. 2, the mechanical part 42 is disposed in a case 41, is used as a mold for molding the case 41, and a periphery of the mechanical part is molded. The case 41 and the mechanical part 42 are fixed by the main circuit unit 20. A fixing structure may be a screw stopper or a pin structure.

[0025] FIG. 3 is another functional configuration schematic diagram showing the vacuum interrupter according to the present embodiment. In FIG. 3, the same components as those in FIG. 2 are denoted by the same reference numerals, and description thereof is omitted. FIG. 3 is different from FIG. 2 in that an electromagnet 46 is provided as the drive source 43, and a plunger 47, a coupling component contact pressure spring 48, and a cutoff spring 49 are provided as the mechanical part 42.

[0026] When components other than the mechanical part in the operation unit are placed outside the mold for insulation from a high-voltage part of the main circuit unit, an electric circuit part of the operation unit cannot be physically connected to the mechanical part. Therefore, the opening and closing part of the main circuit unit can be operated by using the electromagnet 46 of a non-contact type as the drive source 43 and driving the plunger 47 serving as the mechanical part 42 in a non-contact manner. Further, a state in the mold can be detected by adopting a non-contact type for the auxiliary circuit 44 such as a proximity sensor or a magnetic sensor and the other component 45 such as an operation counter or a thermometer.

[0027] In the present embodiment, since the main circuit unit and the mechanical part are covered with a mold as a whole, the main circuit unit and the mechanical part may be affected by heat generated during energization. Therefore, the case 41 is formed of, for example, an aluminum casting, and heat generation of a conductor portion is prevented by dissipating heat by the case 41.

[0028] As a method of connecting the movable conductor of the main circuit unit 20 pulled out to the outside of the vacuum interrupter 1 to the bushing conductor 12A, the movable conductor and the bushing conductor are connected by Copel, braided wires, a multi-contact, or the like.

[0029] Further, since the main circuit unit and the mechanical part are covered with the mold as a whole, maintenance of the mechanical part in the mold becomes difficult. To solve this problem, a low-friction material may be used for a bearing, and the bearing may be a grease free bearing without adjustment. Alternatively, the mold of the main circuit unit and the mechanical part may be divided, and maintenance may be performed by removing a part of the mold. In the case of dividing the mold, the mold needs to be configured such that dielectric breakdown does not occur at a resin joint. Therefore, a structure in which a distance between joint portions is increased or a fitting structure in which a joint portion is fitted via an elastic body may be used so that surface pressure at the resin joint is increased. Further, insulating grease or a sealing member such as an O-ring may be used for a joint portion.

[0030] Since a curing temperature during mold casting is, for example, 140°C, the mechanical part of the operation unit may be broken at the curing temperature. This problem can be coped with by selecting a component that matches a temperature specification.

[0031] Further, an entire sealing structure before mold casting. can be handled by covering the mechanical part with a case and sealing the case with a mating surface with a conductor or the like of the main circuit unit.

[0032] Since the vacuum interrupter according to the present embodiment does not require the insulating operation rod 30, the vacuum interrupter can be reduced in weight, and further, since the main circuit unit and the mechanical part are covered with a mold as a whole, a sound generated during an operation of the opening and closing part is confined in the mold, and thus noises can be reduced.

[0033] As described above, according to the present embodiment, it is possible to provide a vacuum interrupter that does not require an insulating operation rod and can be reduced in size by directly coupling the operation unit to the main circuit unit and molding the operation unit and the main circuit unit from resin.

[0034] The embodiment has been described, and according to the invention, an amount of used materials can be reduced by reducing the size of the vacuum interrup-

ter. Therefore, an amount of carbon emissions can be reduced and global warming can be prevented, which contributes particularly to energy of Item 7 for realizing sustainable development goals (SDGs).

[0035] The invention is not limited to the above-described embodiment, and includes various modifications. For example, although the vacuum interrupter for a railway vehicle has been described as an example in the above-described embodiment, the invention is also applicable to a switch that handles a high voltage and includes a circuit breaker, a load switch, and the like. The embodiment has been described in detail to facilitate understanding of the invention, and the invention is not necessarily limited to those including all the configurations described above.

Reference Signs List

[0036]

1: vacuum interrupter
3: stationary electrode
5: movable electrode
6: arc shield
10A, 10B, 10C: electrical connection portion
12A, 12B, 12C: bushing conductor
15: solid insulating member
20: main circuit unit
30: insulating operation rod
31: air insulating space
40: operation unit
41: case
42: mechanical part
43: drive source
44: auxiliary circuit
45: other component
46: electromagnet
47: plunger
48: coupling component contact pressure spring
49: cutoff spring
50, 51: mold insulator
70, 80: vacuum interrupter
71: base

Claims

1. A switch comprising:

a main circuit unit including a vacuum interrupter provided with an opening and closing part having a stationary electrode and a movable electrode to be separated from or brought into contact with the stationary electrode, a first bushing conductor electrically connected to a stationary conductor that is connected to the stationary electrode and is pulled out to the outside of the vacuum interrupter, and a second bushing conductor electrically connected to a movable conductor that is connected to the movable electrode and is pulled out to the outside of the vacuum interrupter; and

an operation unit directly coupled to the movable conductor pulled out to the outside of the vacuum interrupter and configured to operate the opening and closing part by moving the movable electrode, wherein

the operation unit is integrally molded with the main circuit unit using a solid insulating member to form a mold.

2. The switch according to claim 1, wherein

a mechanical part of the operation unit and the main circuit unit are molded using the solid insulating member to form a mold, and

a drive circuit configured to drive the mechanical part is disposed outside the mold.

3. The switch according to claim 2, wherein
an auxiliary circuit configured to monitor a state of the opening and closing part is disposed outside the mold.

4. The switch according to claim 2, wherein
other component other than the mechanical part of the operation unit is disposed outside the mold.

5. The switch according to claim 4, wherein
the other component is an operation counter or a thermometer.

6. The switch according to claim 2, wherein
the drive circuit drives the mechanical part in a non-contact manner.

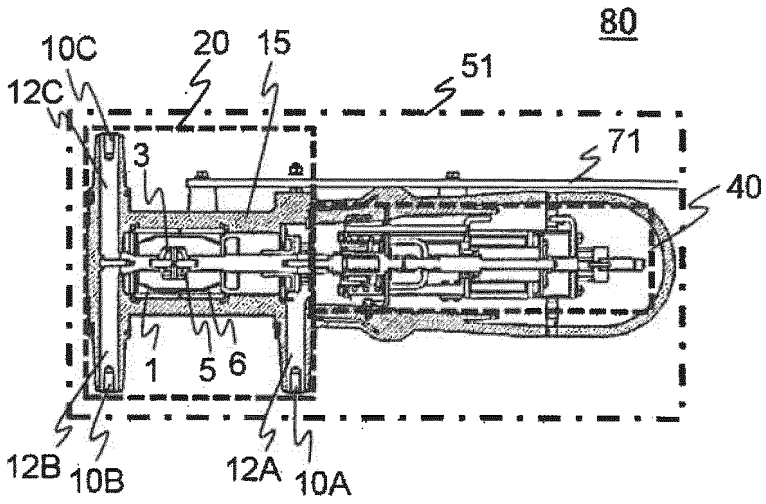
7. The switch according to claim 1, wherein
a surface of the mold is grounded.

8. The switch according to claim 2, wherein
the mechanical part is disposed in a case, the case is sealed at a mating surface with the main circuit unit, and the main circuit unit and the case are integrally molded.

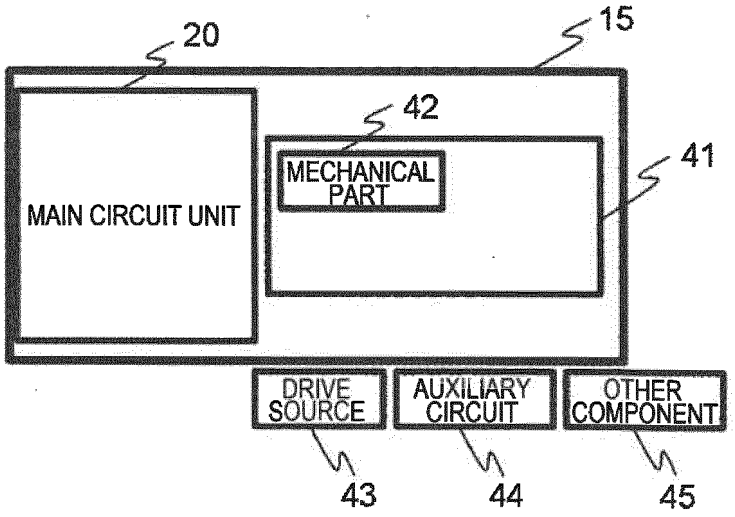
9. The switch according to claim 8, wherein
the case is made of aluminum and dissipates heat generated during energization.

10. The switch according to claim 1, wherein
the movable conductor of the main circuit unit pulled out to the outside of the vacuum interrupter and the second bushing conductor are connected by Copel, a braided wire, or a multi-contact.

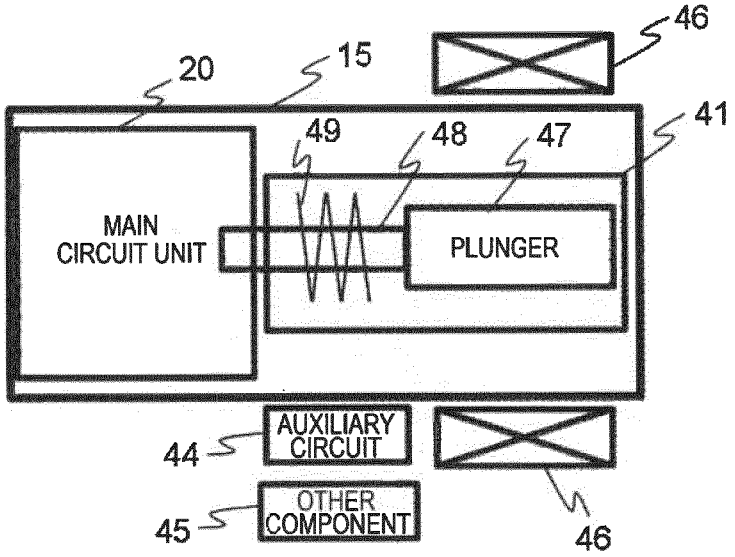
[FIG. 1]


80
10C
20
15
51
12C
3
71
40
1
5
6
12B
10B
12A
10A

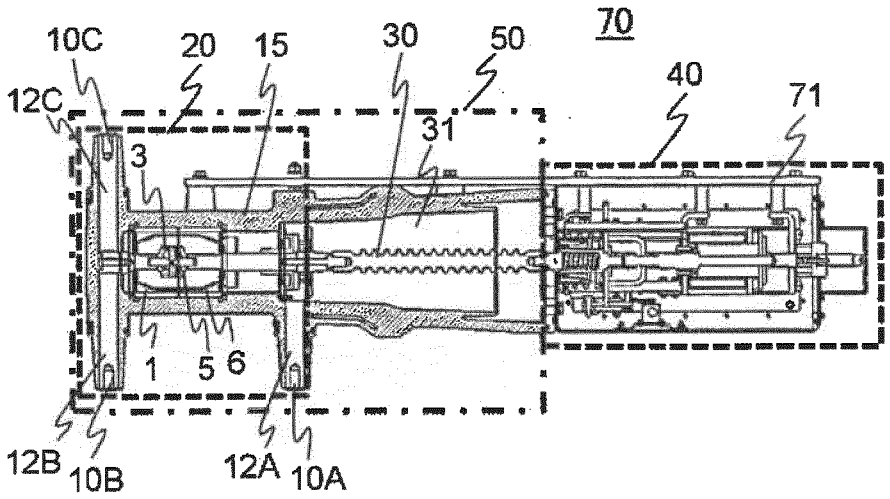
[FIG. 2]


20
15
42
MECHANICAL PART
41
MAIN CIRCUIT UNIT
DRIVE SOURCE
AUXILIARY CIRCUIT
OTHER COMPONENT
43
44
45

[FIG. 3]


46
20
15
41
49
48
47
MAIN
CIRCUIT UNIT
PLUNGER
AUXILIARY
CIRCUIT
44
OTHER
COMPONENT
45
46

[FIG. 4]


10C
20
15
30
50
70
12C
40
71
31
3
1
5
6
12B
10B
12A
10A

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/047439

A. CLASSIFICATION OF SUBJECT MATTER

H01H 33/662(2006.01)i; ***H01H 33/666***(2006.01)i
FI: H01H33/662 R; H01H33/666 L

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)

H01H33/662; H01H33/666

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 1971-2022
Registered utility model specifications of Japan 1996-2022
Published registered utility model applications of Japan 1994-2022

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.
Y	JP 2003-16889 A (MITSUBISHI ELECTRIC CORP) 17 January 2003 (2003-01-17) paragraphs [0016]-[0037], [0044], fig. 1-4	1-10
Y	JP 2003-31091 A (MITSUBISHI ELECTRIC CORP) 31 January 2003 (2003-01-31) paragraph [0013], fig. 1	1-10
Y	JP 2020-87593 A (HITACHI INDUSTRY EQUIPMENT SYSTEMS CO LTD) 04 June 2020 (2020-06-04) paragraphs [0013]-[0021], fig. 1-2	3
Y	JP 2018-147642 A (HITACHI INDUSTRY EQUIPMENT SYSTEMS CO LTD) 20 September 2018 (2018-09-20) paragraphs [0018]-[0028], fig. 1-2	5

☐ 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
28 January 2022	**08 February 2022**

Name and mailing address of the ISA/JP	Authorized officer
Japan Patent Office (ISA/JP) **3-4-3 Kasumigaseki, Chiyoda-ku, Tokyo 100-8915** **Japan**	Telephone No.

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

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/047439

Patent document cited in search report	Publication date (day/month/year)	Patent family member(s)	Publication date (day/month/year)
JP 2003-16889 A	17 January 2003	(Family: none)	
JP 2003-31091 A	31 January 2003	(Family: none)	
JP 2020-87593 A	04 June 2020	(Family: none)	
JP 2018-147642 A	20 September 2018	EP 3370244 A1 paragraphs [0018]-[0028], fig. 1-2 CN 108538685 A	

Form PCT/ISA/210 (patent family annex) (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

- JP 2019032994 A **[0004]**