



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
25.03.2020 Bulletin 2020/13

(51) Int Cl.:
H01B 17/54 (2006.01) H01B 17/26 (2006.01)

(21) Application number: **18460058.3**

(22) Date of filing: **24.09.2018**

(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: **ABB Schweiz AG**
5400 Baden (CH)

(72) Inventors:
• **SITKO, Adam**
30-552 Krakow (PL)
• **NOWAK, Remigiusz**
30-691 Krakow (PL)
• **OGANEZOV, Valeri**
Verdun H3E1S1 (CA)

(74) Representative: **Chochorowska-Winiarska, Krystyna**
ABB Sp. z o. o.
ul. Zeganska 1
04-713 Warszawa (PL)

(54) **GAS INSULATED ELECTRICAL SWITCHGEAR**

(57) The subject of the invention is a gas insulated electrical switchgear (1) placed in an enclosure (2) and provided with at least one bushing (4) for transferring electric energy through the enclosure of the switchgear. The bushing (4) has a conductor (5) for powering the switchgear (1) and has a form of a the cooling device which is integrated in the conductor (5) of the bushing

(4). The cooling device is a heat pipe filled with a working fluid (8). One end of the heat pipe forms an electrical bottom terminal (11) connected with a conductive part of the switchgear (1) whereas the other end of the heat pipe forms an electrical top terminal (12) placed outside the enclosure (1) closing the switchgear (1).

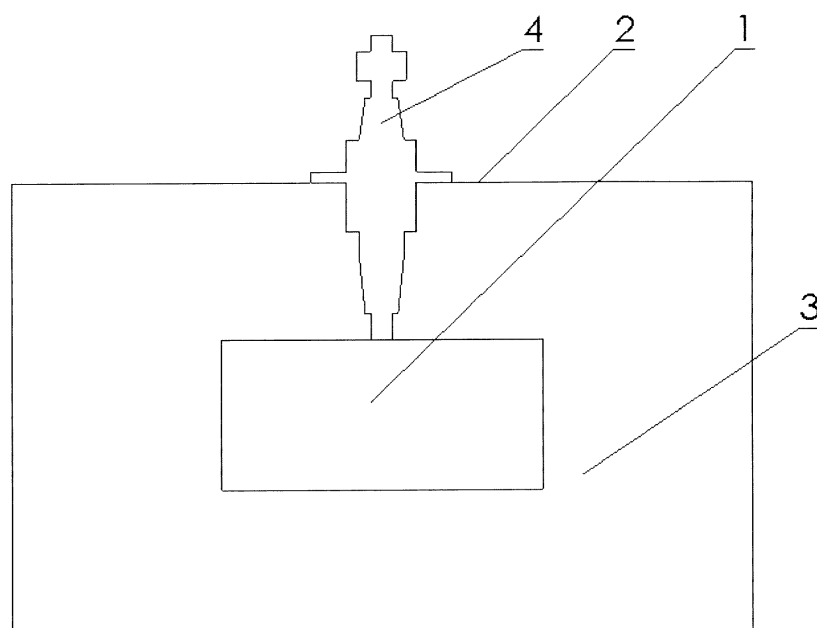


Fig. 1

Description

[0001] The subject of the invention is a gas insulated electrical switchgear placed in the enclosure and provided with at least one bushing for transferring electric energy through the enclosure of the switchgear.

[0002] From patent EP2494567 there is known a medium voltage apparatus closed in the enclosure and having a device for cooling the medium voltage apparatus. The device for cooling is using heat pipes, partially consisted in a casing of the apparatus. The heat pipe is filled with a working fluid. The part embedded into casing has an evaporator being in contact with current conducting part of the device connected by sleeve with condensation device placed outside the device. The sleeve is made of electrically insulating and thermally well conductive material. The disadvantage of this solution is the need of using insulating sleeve which must provide electrical separation between current path of medium voltage apparatus and the casing. In addition this arrangement require to provide a space for placing there a separate auxiliary cooling system, thus the size of the medium voltage apparatus need to be extended.

[0003] From patent US7253379 there is known a high voltage circuit breaker with cooling system in the form of a heat pipe. The heat pipe is a device having a sealed chamber for working fluid circulation. The working fluid circulates in liquid and gaseous phase. The circulation allows effective heat transfer between evaporator, where heat is absorbed by evaporation process, and condenser, where heat is released during condensation. The working fluid used in the heat pipe must have suitable dielectric strength because it circulates between evaporator placed on a conductive part of the circuit breaker being on high electrical potential and the condenser attached to grounded housing.

[0004] The essence of the present invention having a cooling device with a phase - change heat transfer fluid is that the switchgear is equipped with at least one bushing with a conductor for powering the switchgear and in the same time a cooling device which is integrated in the conductor (5) of the bushing (4) that forms a heat pipe. The heat pipe is filled with a working fluid. One end of the heat pipe forms an electrical bottom terminal connected with a conductive part of the switchgear whereas the other end of the heat pipe forms an electrical top terminal placed outside the enclosure of the switchgear. The heat pipe has a vaporizing part situated in the proximity of the bottom terminal and a condensing part situated in the proximity of the top terminal.

[0005] Preferably an upper part of the conductor of the bushing is connected with a heat sink device.

[0006] Preferably a bottom part of the conductor of the bushing together with the bottom terminal are free of an insulation.

[0007] Preferably the inner side of the cylinder of the conductor of the bushing is covered with a wick.

[0008] Preferably the wick has a form of a well-devel-

oped surface structure made on the inner side of the cylinder of the conductor of the bushing.

[0009] Alternatively the wick has a form of a separate layer deposited on the inner side of the cylinder of the conductor of the bushing.

[0010] The advantage of the present invention is that the cooling device is integrated within existing and irreplaceable part of the switchgear, i.e. the conductor of the bushing, what does not require any additional electrical insulation. Moreover, the cooling device is embedded in a current path of the switchgear what causes that the heat is transferred directly out of place where it is generated by Joule's heating. Such arrangement allows for design of a compact electrical switchgear without any additional volume for placing there a separate cooling device.

[0011] The present invention is presented in an exemplary embodiment were:

Fig. 1 shows the switchgear placed in the enclosure and connected with the bushing in a schematic view,

Fig. 2 shows the bushing from fig.1 in a cross-section,

Fig. 3 shows the bottom part of the bushing from fig. 2 in a cross-section,

Fig. 4 shows the upper part of the bushing from fig.2.

[0012] A switchgear 1 is placed entirely in an enclosure 2 filled with a gaseous medium 3. Conductive part of the switchgear is connected with a bushing 4 for transferring electric energy delivered through the enclosure 2. The gaseous medium 3 could be air or another gas for example SF₆ or any other gas which provides sufficient voltage withstand ability. The bushing 4 is partially placed inside the enclosure and partially outside the enclosure.

[0013] The bushing 4 has a conductor 5 made of copper or aluminum, in the form of a metal cylinder closed on both ends. The conductor is surrounded by an insulator 6 made of thermoplastic or thermosetting material which provides sufficient thickness for electrical insulation in relation to the rating voltage of the switchgear. The insulator 6 extends radially along the axis of the conductor 5 but not covering the both ends of the conductor 5. The insulator 6 is attached to a flange 7 made of steel or aluminum for mounting the bushing in an opening made in a wall of the enclosure 2, what is not presented in the drawing. Inside the conductor 5 there is a working fluid 8 in liquid and gaseous state in thermodynamic equilibrium. The conductor 5 with the working fluid 8 form a device commonly known as a heat pipe. The working fluid 8 must be delivered in amount assured a space for condensation in a section provided for heat dissipation and in amount sufficient to prevent full evaporation of the working fluid during maximum operating temperatures provided for the switchgear. Typical material applicable

for working fluid are water, methanol or acetone. To enhance evaporation and condensation, the inner side of the cylinder 5 is covered with a wick 9. The wick 9 may be realized by preparing a special surface structure of inner side of the cylinder of the conductor 5, e.g. by grooving of the surface for receive well-developed surface structure, or by deposition a separate layer of material with fabric or mesh-like structure characterized by high thermal conductivity. The upper end of the bushing protruding from the enclosure 2 is equipped with a heat sink device 10 for better heat dissipation from the upper end of the conductor 5. The heat sink is made of material with high thermal conductivity. The ends of the conductor 5 form a bottom terminal 10 and a top terminal 12. The both terminals 10 and 12 must be free of insulation to provide good electrical connection and heat transfer. The switchgear 1 device is connected with electric line by top terminal 12, what is not presented in the picture.

[0014] During the work of the switchgear 1 Joule's heat generated by conductive part of the switchgear 1 is transferred by the bottom terminal 11 and heats the fluid 8 placed in the bottom part of the conductor 8. A new thermodynamic equilibrium is reached, where working fluid is boiling in bottom part of the conductor what is presented in Fig.3 by the arrows. It is important that the bottom part of the conductor 8 is free of any insulation protection what is needed for electricity conduction and heat transfer from conductive part of the switchgear 1 to heat pipe. For phase change process and working fluid transport enhancements wick 8 is used. When the evaporated fluid 8 reaches the top part of the conductor 5 the gaseous phase of working fluid 8 starts to condensate at wick 9 and inner wall of conductor. The wick 9 supports liquid phase transport as it was indicated in the drawing 4 by dotted arrows. Heat is transferred via conductor 5 to the heat sink 10, which enhances heat dissipation. The presented conductor 5 of the bushing 4 plays role of the heat pipe placed inside the busing.

the top terminal (12).

2. Gas insulated electrical switchgear according to claim 1, **characterized in that** an upper part of the conductor (5) is connected with a heat sink device (10).
3. Gas insulated electrical switchgear according to claim 1-2, **characterized in that** a bottom part of the conductor (5) together with the bottom terminal (11) are free of an insulation (8).
4. Gas insulated electrical switchgear according to claim 1-3, **characterized in that** the inner side of the cylinder of the conductor (5) is covered with a wick (9).
5. Gas insulated electrical switchgear according to claim 4, **characterized in that** the wick (9) has a form of a well-developed surface structure made on the inner side of the cylinder of the conductor (5).
6. Gas insulated electrical switchgear according to claim 4, **characterized in that** the wick (9) has a form of a separate layer deposited on the inner side of the cylinder of the conductor (5).

Claims

1. Gas insulated electrical switchgear (1) closed in an enclosure (2) fulfilled with a gaseous medium (3), having a cooling device using a phase-change heat transfer fluid **characterized in that** the switchgear is equipped with at least one bushing (4) with a conductor (5) for powering the switchgear (1) and the cooling device is integrated in the conductor (5) of the bushing (4) forms a heat pipe filled with a working fluid (8), wherein one end of the heat pipe forms an electrical bottom terminal (11) connected with a conductive part of the switchgear (1) whereas the other end of the heat pipe forms an electrical top terminal (12) placed outside the enclosure (1) closing the switchgear (1); the heat pipe has a vaporizing part situated in the proximity of the bottom terminal (11) and a condensing part situated in the proximity of

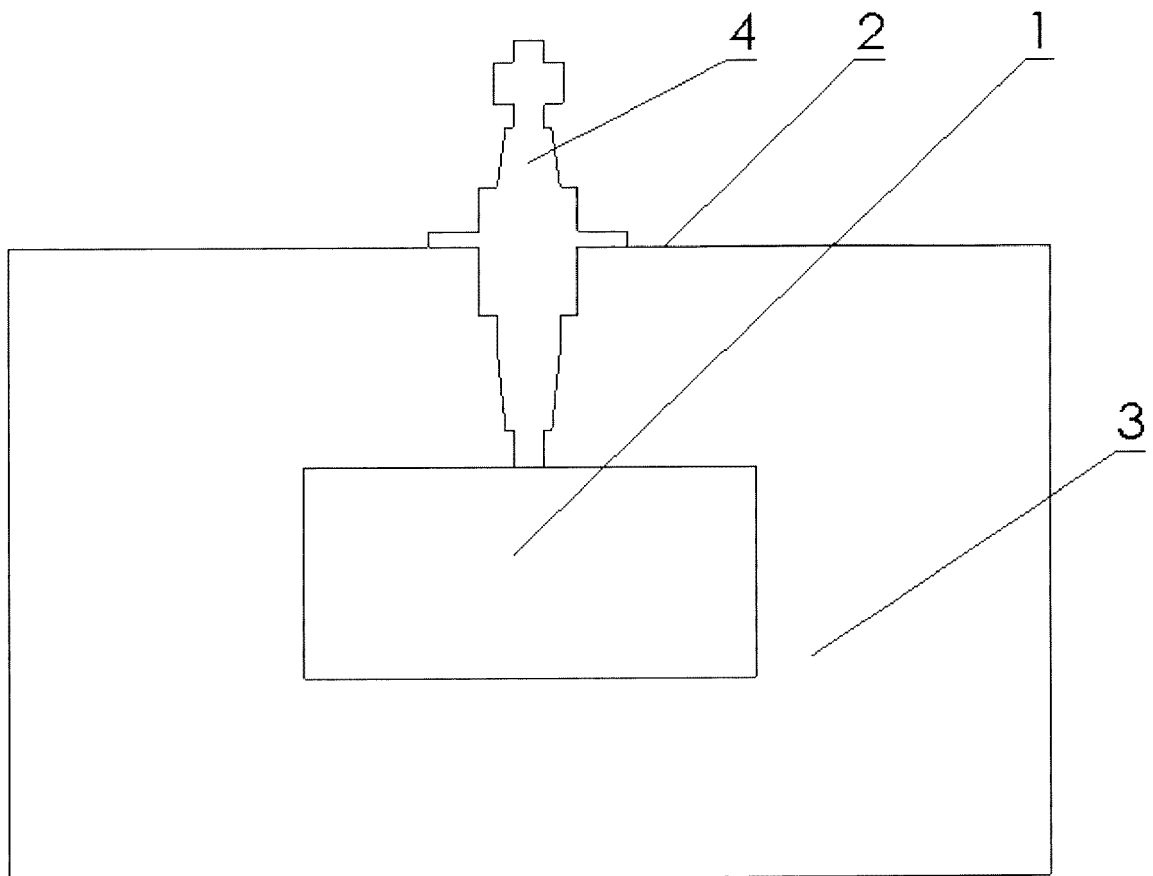


Fig. 1

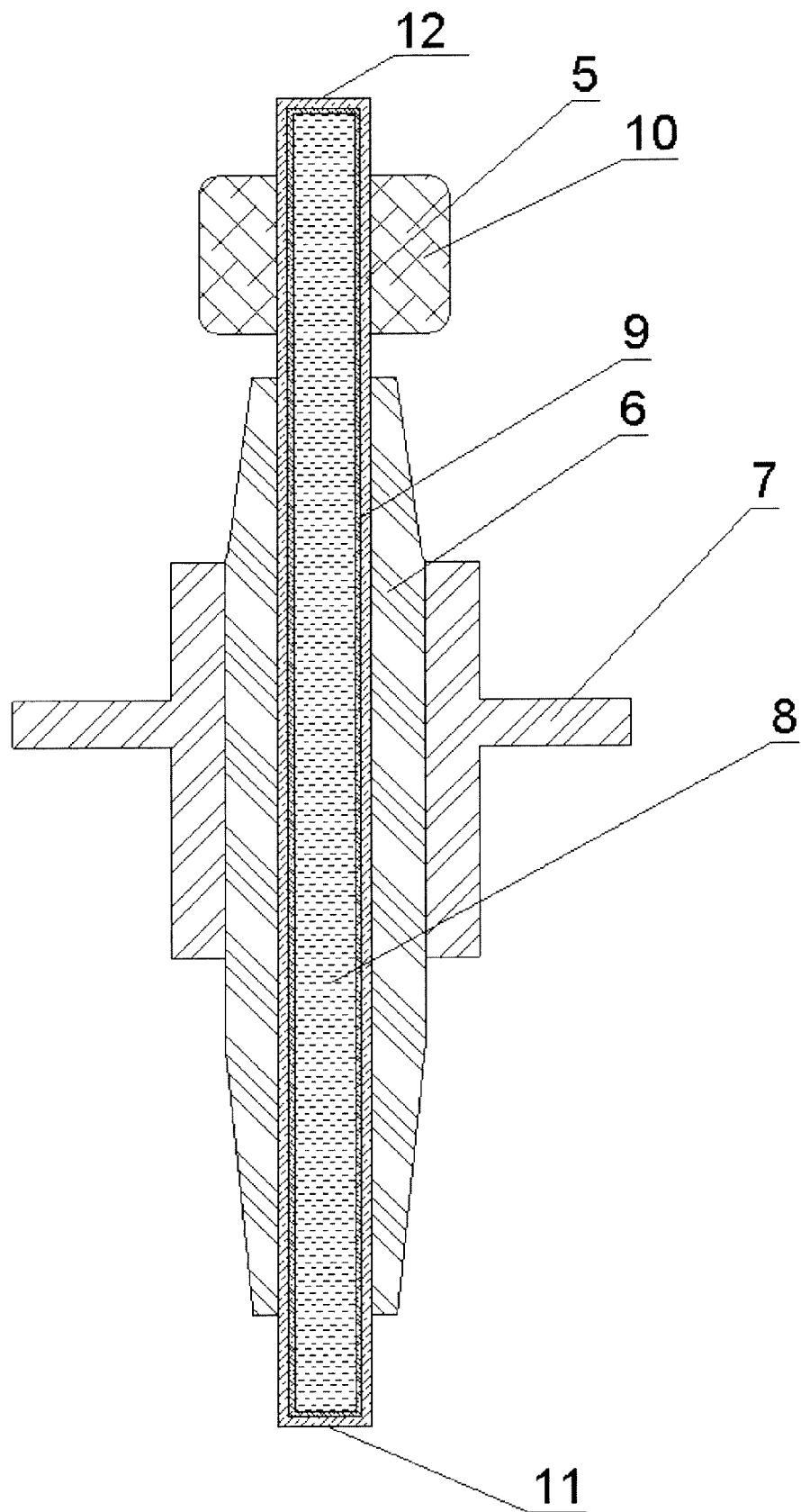


Fig.2

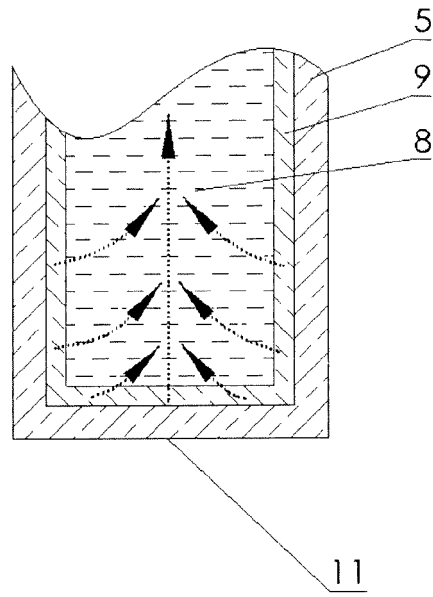


Fig. 3

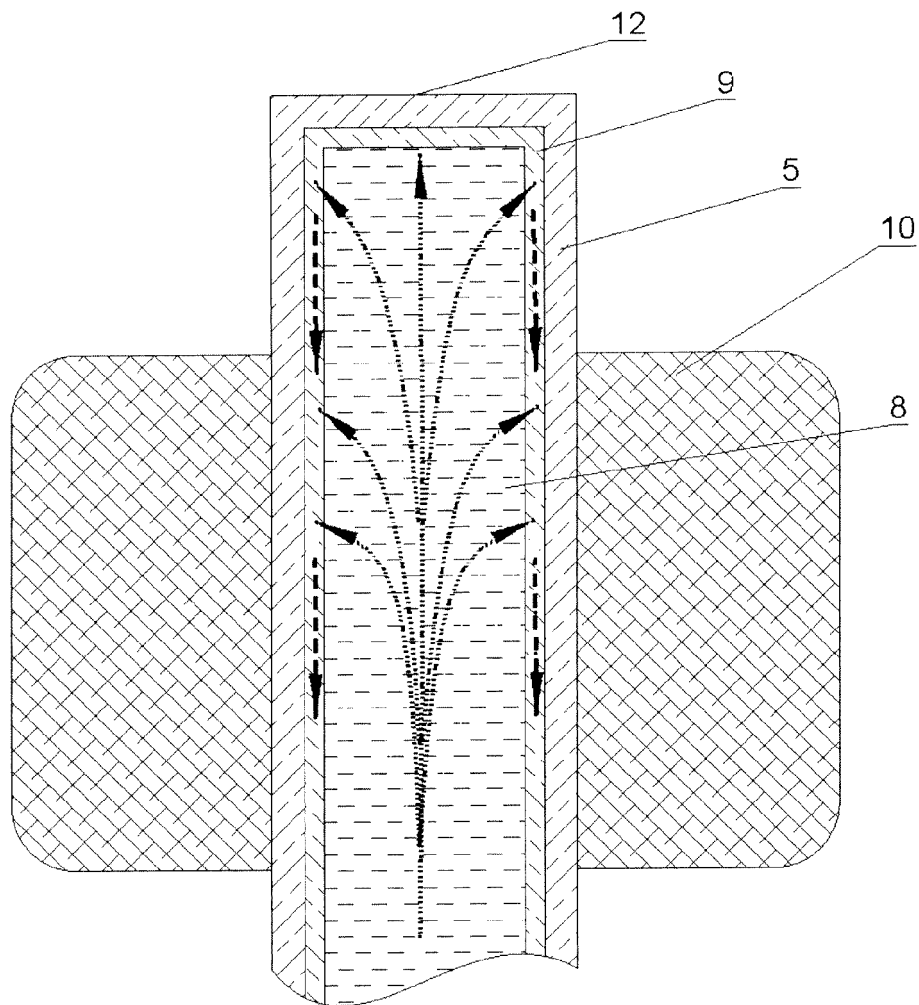


Fig. 4



EUROPEAN SEARCH REPORT

 Application Number
 EP 18 46 0058

5

10

15

20

25

30

35

40

45

50

55

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	DE 77 28 374 U1 (FELTEN & GUILLEAUME KARLSBERG AG) 29 March 1979 (1979-03-29) * figures 1,2 *	1-6	INV. H01B17/54
X	US 4 123 618 A (CUSHING GEORGE B ET AL) 31 October 1978 (1978-10-31) * figure 4 *	1-6	ADD. H01B17/26
X	EP 2 704 157 A1 (ABB TECHNOLOGY LTD [CH]) 5 March 2014 (2014-03-05) * the whole document *	1-6	
X	DE 10 2016 201907 A1 (SIEMENS AG [DE]) 10 August 2017 (2017-08-10) * the whole document *	1-6	
A	WO 2017/015889 A1 (GEN ELECTRIC [US]; TU ZHIYU [CN]; WANG WEI [CN]; REN XUHUI [CN]) 2 February 2017 (2017-02-02) * figures 3,5 *	4-6	
A	US 3 764 765 A (OLASHAW W) 9 October 1973 (1973-10-09) * figures 5, ref.63 *	4-6	TECHNICAL FIELDS SEARCHED (IPC) H01B
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 22 February 2019	Examiner Overdijk, Jaco
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	

 1
 EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 46 0058

5

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

22-02-2019

10

15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 7728374 U1	29-03-1979	NONE	
US 4123618 A	31-10-1978	AU 515382 B2 CA 1089944 A JP S52150591 A US 4123618 A	02-04-1981 18-11-1980 14-12-1977 31-10-1978
EP 2704157 A1	05-03-2014	CN 203950620 U EP 2704157 A1	19-11-2014 05-03-2014
DE 102016201907 A1	10-08-2017	DE 102016201907 A1 EP 3387656 A1 WO 2017137193 A1	10-08-2017 17-10-2018 17-08-2017
WO 2017015889 A1	02-02-2017	CN 107851526 A DE 112015006736 T5 US 2018261405 A1 WO 2017015889 A1	27-03-2018 05-04-2018 13-09-2018 02-02-2017
US 3764765 A	09-10-1973	NONE	

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

- EP 2494567 A [0002]
- US 7253379 B [0003]