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

(11) EP 3 355 323 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
01.08.2018 Bulletin 2018/31

(51) Int Cl.:
H01F 27/12 *(2006.01)*

(21) Application number: **17153608.9**

(22) Date of filing: **27.01.2017**

(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: **General Electric Technology GmbH**
5400 Baden (CH)

(72) Inventors:
- **STIRL, Tobias**
47918 Tönisvorst (DE)
- **HOBA, Günther**
41189 Mönchengladbach (DE)

(74) Representative: **Fischer, Michael Maria et al**
General Electric Technology GmbH
GE Corporate Intellectual Property
Brown Boveri Strasse 7
5400 Baden (CH)

(54) COOLING ASSEMBLY FOR A HIGH VOLTAGE ASSEMBLY AND METHOD TO OPERATE A COOLING ASSEMBLY FOR A HIGH VOLTAGE ASSEMBLY

(57) It is proposed a cooling assembly (2) for connecting to a compartment (18) of a high voltage assembly (16) via a flow line (4) and a return line (6), the cooling assembly (2) comprising: a heat exchange assembly (8) adapted to dissipate heat from the insulation liquid (10) to the environment; and a pump (14) arranged at the flow line (4) or the return line (6) and being operable at variable speeds.

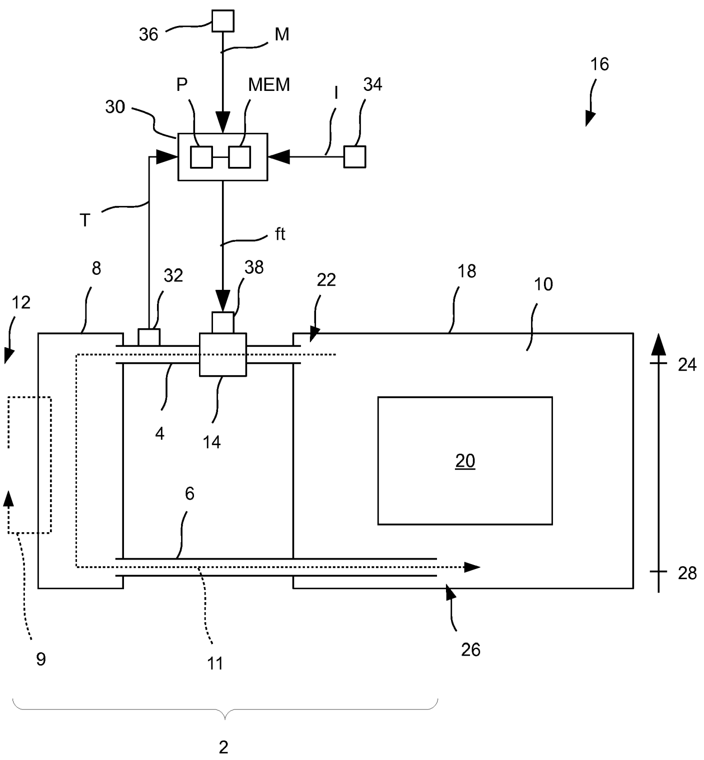

Fig. 3

EP 3 355 323 A1

Description

FIELD OF THE INVENTION

[0001] The present invention relates to a cooling assembly for a high voltage assembly and to a method to operate the cooling assembly.

BACKGROUND

[0002] Known high voltage assemblies like oil immersed power transformers or oil immersed reactors comprise a cooling assembly which is adapted to an expected ambient temperature range and adapted to the configuration of the high voltage assembly. Furthermore, it is known that such a cooling assembly comprises a pump which comprises an on-state and an off-state only.

[0003] Furthermore, legislative authorities push the need for "green" transformers implicating that unnecessary energy consumption is avoided.

SUMMARY

[0004] In view of the prior art, it is an object of the present disclosure to improve a cooling assembly for a high voltage assembly and a method to operate a cooling assembly for a high voltage assembly.

[0005] According to a first aspect of this disclosure it is proposed a cooling assembly for connecting to a compartment of a high voltage assembly via a flow line and a return line, the cooling assembly comprises a heat exchange assembly adapted to dissipate heat from the insulation liquid to the environment; and a pump arranged at the flow line or the return line and being operable at variable speeds.

[0006] Advantageously the cooling power of the heat exchange assembly can be adapted as it is available a continuously variable speed control of the pump. Therefore, the cooling performance can be optimized and an increase in overload capacity is possible. Furthermore, unnecessary losses are avoided as the pump can be operated at less than 100 % of the possible speed. Also inrush currents are limited as the variable speed control allows starting the pump with a low speed. The proposed cooling assembly also provides to decrease weight and dimension of the cooling assembly as forced circulation through the cooling assembly does not rely on natural convection which would implicate large surfaces exposed to the environment.

[0007] A further advantage relies in standardization, which means that one type of pump can be used for a plurality of speed and sound requirements. Consequently, one type of pump can be used for a plurality of types of high voltage assemblies. This has also an advantageous impact on the reduction of service and maintenance costs.

[0008] An advantageous embodiment is characterized in that a target volumetric flow rate of the insulation liquid is determined, wherein the speed of the pump is controlled in dependence on the target volumetric flow rate.

[0009] An advantageous embodiment is characterized in that the target volumetric flow rate is determined in dependence on a load current of the high voltage assembly. Consequently, temperature variations of the insulation liquid over time can be reduced. This results in less breathing of the high voltage assembly which has a positive effect on ageing of the whole oil/paper-insulation. Therefore life expectancy of the whole high voltage assembly is increased.

[0010] An advantageous embodiment is characterized in that the target volumetric flow rate is determined in dependence on a temperature of the insulation liquid. Consequently, temperature variations of the insulation liquid over time can be reduced. This results in less breathing of the high voltage assembly which has a positive effect on ageing of the whole oil/paper-insulation. Therefore life expectancy of the whole high voltage assembly is increased.

[0011] An advantageous embodiment is characterized in that the target volumetric flow rate is determined to a base rate if the temperature and/or the load current falls below a threshold. Compared with an off-state of the pump the base rate advantageously provides that any failure of the pump can be detected and resolved immediately. Furthermore, the insulation liquid remains in circulation. Moreover, sound emissions of the pump or cooling fans are reduced when compared to a singular on-state.

[0012] An advantageous embodiment is characterized in that the target volumetric flow rate is determined in dependence on a characteristic curve linking the target volumetric flow rate and the temperature of the insulation liquid or the target volumetric flow rate and the load current.

[0013] An advantageous embodiment is characterized in that the characteristic curve comprises partly a linear relationship between the target volumetric flow rate and the temperature of the insulation liquid or the target volumetric flow rate and the load current.

[0014] An advantageous embodiment is characterized in that the target volumetric flow rate is determined in dependence on a manual input of a manual input unit, wherein the manual input overrides the calculated target volumetric flow rate. Therefore, manual operation is advantageously is still possible.

[0015] An advantageous embodiment is characterized in that the target volumetric flow rate is determined by a closed loop control. A further reduction in temporal drift of the temperature of the insulation liquid can be achieved.

[0016] An advantageous embodiment is characterized in that the cooling assembly comprises a radiator, and wherein the pump is a propeller pump.

[0017] An advantageous embodiment is characterized in that the cooling assembly comprises an oil-to-air-cooler or an oil-to-water cooler, and wherein the pump is an inline pump. Another aspect of this disclosure is directed to a high voltage assembly comprising the proposed cooling assembly, and the compartment containing an active component surrounded by the insulation liquid, wherein the cooling assembly is connected with the compartment via the flow line and the return line.

[0018] Another aspect of this disclosure is directed to a method to operate a cooling assembly for a high voltage assembly being connected to a compartment of the high voltage assembly via a flow line and a return line, the cooling assembly comprising: a heat exchange assembly adapted to dissipate heat from the insulation liquid to the environment; and the method comprising operating a pump arranged at the flow line or the return line at variable speeds. The advantages of the method are outlined above.

[0019] A further aspect of this disclosure is directed to a control unit configured to execute the proposed method.

BRIEF DESCRIPTION OF THE FIGURES

[0020]

Figures 1 and 3 show a schematic cooling assembly for a high voltage assembly, respectively;

Figure 3 shows schematic depiction of the high voltage assembly;

Figures 4 and 6 show a schematic block diagram of open-loop control, respectively;

Figures 5 and 7 show a characteristic curve, respectively;

Figure 8 shows a schematic block diagram of a closed loop control; and

Figure 9 shows a schematic flow diagram.

DESCRIPTION OF THE EMBODIMENTS

[0021] Figure 1 shows a schematic depiction of a cooling assembly 2 for a high voltage assembly. The cooling assembly 2 is adapted to be connected to a compartment of the high voltage assembly via a flow line 4 and a return line 6. A heat exchange assembly 8 is adapted to dissipate heat from an insulation liquid 10 passing through the heat exchange assembly 8 to the environment 12. A pump 14 is arranged at the flow line 4 and is operable at variable speeds.

[0022] Figure 2 shows a further schematic cooling assembly 2 for a high voltage assembly. With difference to figure 1 the pump 14 is arranged at the return line 6.

[0023] Figure 3 shows schematic depiction of the high voltage assembly 16. The high voltage assembly 16 is for example a high voltage transformer or a high voltage reactor. The heat exchange assembly 8 comprises a heat dissipating component 9 like a radiator or an oil-to-air-cooler or an oil-to-water-cooler. The heat exchange assembly 8 realizes an insulation liquid path 11 to ingest high temperature insulation liquid 10 and to emit low temperature insulation liquid 10 into the compartment 18. Inside the compartment 18 of the high voltage assembly 16 it is arranged an active component 20 comprising a core and windings. The active component 20 is surrounded by the insulation liquid 10.

[0024] An inlet 22 of the flow line 4 is arranged at an upper part 24 of the compartment 18. An outlet 26 of the return line 6 is arranged at a bottom part 28 of the and inside the compartment 18. The outlet 26 is arranged below the active component 20. According to another embodiment the outlet 26 can be arranged outside an area below the active component 20. According to a further embodiment the outlet 26 can be arranged to pass at least partly through the active component 20.

[0025] A controller 30 is configured to determine a target volumetric flow rate ft. To determine the target volumetric flow rate ft the controller 30 comprises a processor P and memory MEM. A temperature sensor 32 is arranged at the flow line 4 to determine a temperature T of the insulation liquid 10 passing through the flow line 4.

[0026] Of course, the temperature sensor 32 can be arranged at another position of the high voltage assembly 16. A unit 34 is configured to determine a load current I of the high voltage assembly 16. The unit 34 can be a sensor or a further control unit. A manual input unit 36 determines a manual input M. The controller 30 is configured to determine the target volumetric flow rate ft in dependence on the temperature T and/or the load current I and/or in dependence on the manual input M.

[0027] The pump 14 comprises power electronics 38 to which the target volumetric flow rate ft is applied. The power electronics 38 is configured to translate the applied target volumetric flow rate ft to a corresponding speed of the pump 14.

[0028] According to an embodiment the high voltage assembly 16 comprises a plurality of cooling assemblies 2, each cooling assembly 2 being connected to the single compartment 18 via a respective flow line 4 and a respective return line 6. Alternatively, the plurality of assemblies 2 is connected to the single compartment 19 via an at least partly conjoint flow line 4 and an at least partly conjoint return line 6. Advantageously, the cooling of the insulation liquid 10 is assured by redundant cooling assemblies 2.

[0029] Figure 4 shows schematic block diagram of open-loop control. The temperature T is supplied to a characteristic curve 40 and a corresponding target volumetric flow rate ft is determined and applied to the pump 14.

[0030] Figure 5 shows the characteristic curve 40 in a schematic way. In a first temperature area TA the target volumetric flow rate ft remains constant at a base rate ftB. In a second temperature area TB a linear relationship between the temperature T and the target volumetric flow rate ft applies. A threshold Tth divides the temperature areas TA and TB. Of course, the relationship between the temperature T and the target volumetric flow rate ft can depart from the linear relationship in the temperature area TB.

[0031] Figure 6 shows schematic block diagram of open-loop control. The load current I is supplied to a characteristic curve 42. A target volumetric flow rate ft corresponding to the load current I is determined and applied to the pump 14.

[0032] Figure 7 shows the characteristic curve 42 in a schematic way. In a first load current area IA the target volumetric flow rate ft remains constant at a base rate ftB. In a second load current area TB a linear relationship between the load current I and the target volumetric flow rate ft applies. A threshold Ith divides the load current areas IA and IB. Of course, relationship between the load current I and the target volumetric flow rate ft can depart from the linear relationship in the load current area IB.

[0033] Figure 8 shows a schematic block diagram of a closed loop control. A block 44 determines a setpoint value Ts as a desired value for the temperature of the insulation liquid 10 inside the compartment 18 or a temperature of the insulation liquid 10 at the temperature sensor 32. At a block 46 a difference D is determined by subtracting the temperature T from the setpoint value Ts. The difference d is applied to a controller 48, for example a proportional plus integral plus derivative element. The controller 48 determines the target volumetric flow rate ft in dependence on the difference D and applies it to the pump 14. The operation of the pump 14 at variable speeds has an impact on the whole high voltage assembly 16 which can be measured by the temperature T.

[0034] Figure 9 shows a schematic flow diagram to operate the cooling assembly 2. In a step 50 the pump 14 is operated at variable speeds.

Claims

1. A cooling assembly (2) for connecting to a compartment (18) of a high voltage assembly (16) via a flow line (4) and a return line (6), the cooling assembly (2) comprising:

   a heat exchange assembly (8) adapted to dissipate heat from the insulation liquid (10) to the environment (12); and
   a pump (14) arranged at the flow line (4) or the return line (6) and being operable at variable speeds.

2. The cooling assembly (2) according to claim 1, wherein a target volumetric flow rate (ft) of the insulation liquid (10) is determined, and wherein the speed of the pump (14) is controlled in dependence on the target volumetric flow rate (tf).

3. The cooling assembly (2) according to claim 2, wherein the target volumetric flow rate (ft) is determined in dependence on a load current (I) of the high voltage assembly (16).

4. The cooling assembly (2) according to claim 2 or 3, wherein the target volumetric flow rate (ft) is determined in dependence on a temperature (T) of the insulation liquid (10).

5. The cooling assembly (2) according to claim 3 or 4, wherein the target volumetric flow rate (ft) is determined to a base rate (ftB) if the temperature (T) and/or the load current (I) falls below a threshold (Tth; Ith).

6. The cooling assembly (2) according to one of the claims 3 to 5, wherein the target volumetric flow rate (ft) is determined in dependence on a characteristic curve (40; 42) linking the target volumetric flow rate (ft) and the temperature (T) of the insulation liquid (10) or the target volumetric flow rate (ft) and the load current (I).

7. The cooling assembly (2) according to claim 6, wherein the characteristic curve (40; 42) comprises partly a linear relationship between the target volumetric flow rate (ft) and the temperature (T) of the insulation liquid (10) or the target volumetric flow rate (ft) and the load current (I).

8. The cooling assembly (2) according to one of the preceding claims, wherein the target volumetric flow rate (ft) is determined in dependence on a manual input (M) of a manual input unit (36), wherein the manual input (M) overrides the calculated target volumetric flow rate (ft).

9. The cooling assembly (2) according to one of the claims 2 to 8, wherein the target volumetric flow rate (ft) is determined by a closed-loop control.

10. The cooling assembly (2) according to one of the preceding claims, wherein the cooling assembly (8) comprises a radiator, and wherein the pump (14) is a propeller pump.

11. The cooling assembly (2) according to one of the claims 1 to 9, wherein the cooling assembly (8) comprises an oil-to-air-cooler or an oil-to-water cooler, and wherein the pump (14) is an inline pump.

12. A high voltage assembly (16) comprising:

    a cooling assembly (2) according to one of the claims 1 to 11, and
    the compartment (18) containing an active component (20) surrounded by the insulation liquid

(10), wherein the cooling assembly (8) is connected with the compartment (18) via the flow line (4) and the return line (6).

13. A method to operate a cooling assembly (2) for a high voltage assembly (16) being connected to a compartment (18) of the high voltage assembly (16) via a flow line (4) and a return line (6), the cooling assembly (2) comprising:

a heat exchange assembly (8) adapted to dissipate heat from the insulation liquid (10) to the environment; and the method comprising:

operating a pump (14) arranged at the flow line (4) or the return line (6) at variable speeds.

14. The method according to the preceding claim for operating the cooling assembly (8) according to one of the claims 2 to 11.

15. A control unit (30) configured to execute the method according to claim 13 or 14.

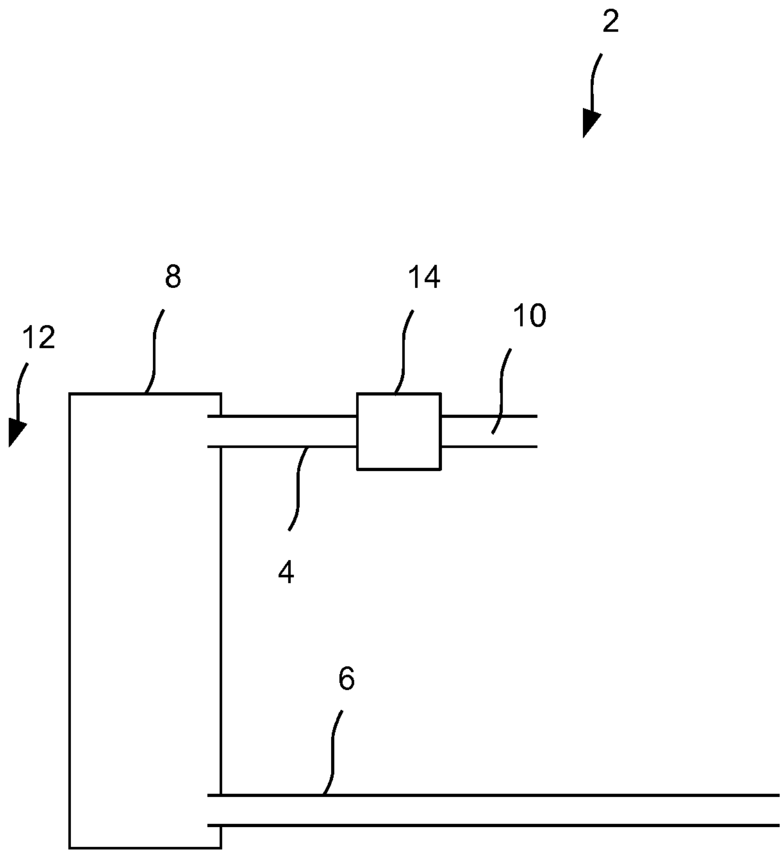

Fig. 1

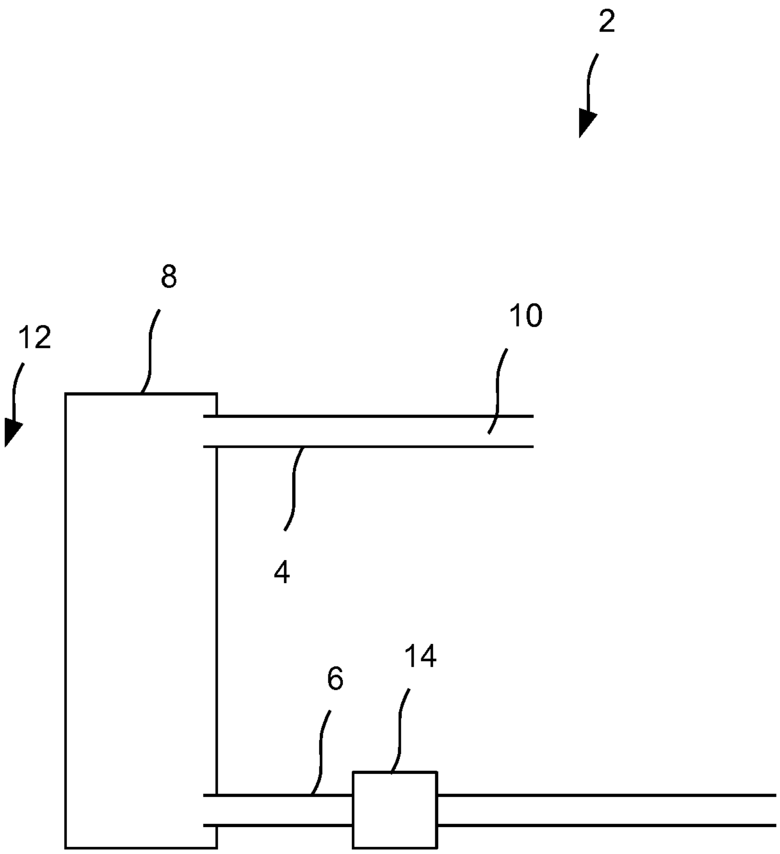

Fig. 2

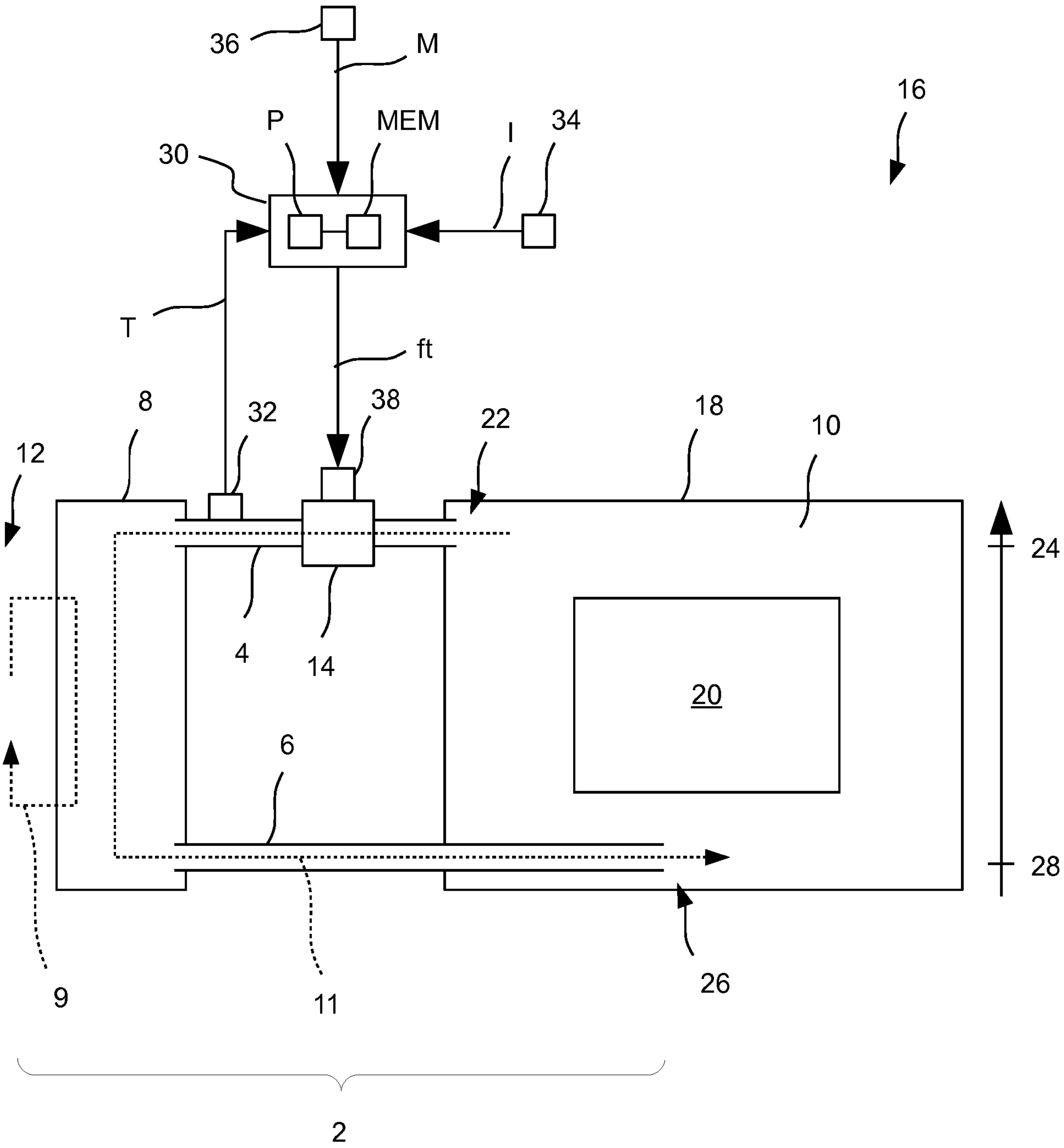

Fig. 3

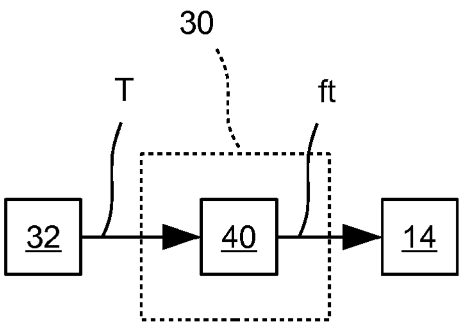

Fig. 4

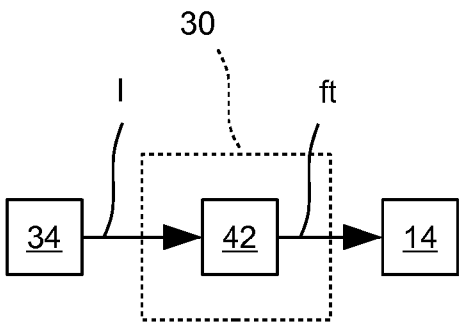

Fig. 6

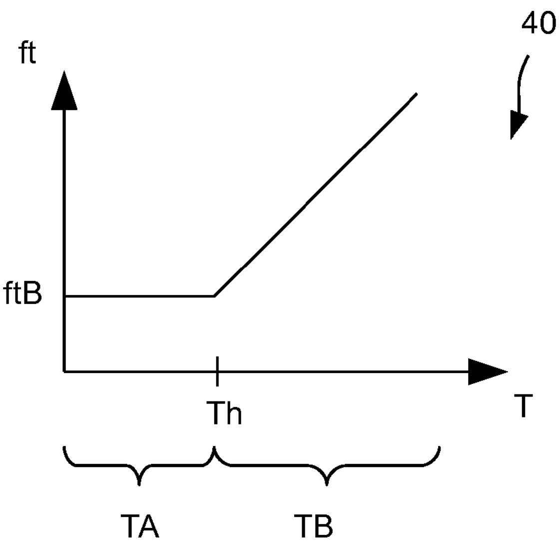

Fig. 5

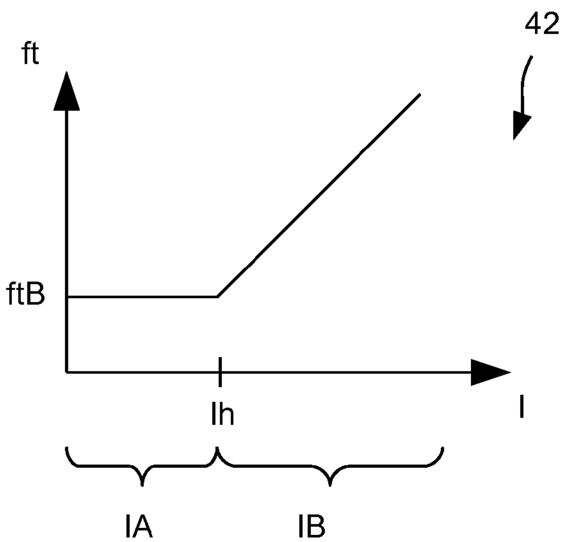

Fig. 7

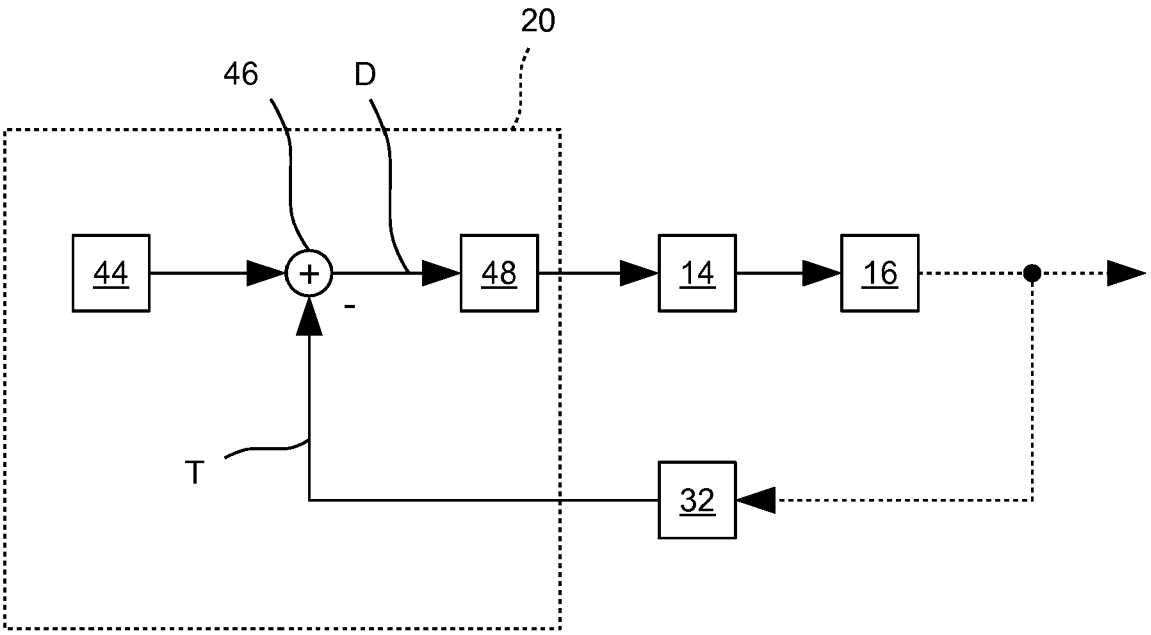

Fig. 8

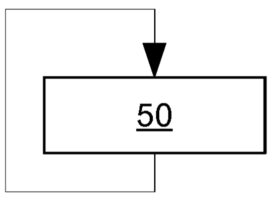

Fig. 9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 17 15 3608

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 Y	US 6 446 027 B1 (O'KEEFFE THOMAS GARY [US] ET AL) 3 September 2002 (2002-09-03) * abstract * * column 1, lines 11-29 * * column 5, lines 24-65; figures 1-3 * -----	1-4,6-15 5	INV. H01F27/12
X	EP 1 750 360 A1 (ABB RESEARCH LTD [CH]) 7 February 2007 (2007-02-07) * abstract * * paragraphs [0005], [0014], [0015]; figure 2 * -----	1,12,13	
Y	US 2004/158428 A1 (BYRD DOUGLAS S [US] ET AL) 12 August 2004 (2004-08-12) * abstract * * paragraphs [0005], [0018], [0019]; figures 1-3 * -----	5	

TECHNICAL FIELDS SEARCHED (IPC)

H01F

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	8 May 2017	Winkelman, André

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

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 17 15 3608

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.

08-05-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6446027 B1	03-09-2002	AR 026883 A1	05-03-2003
		BR 0004254 A	02-05-2001
		CN 1289038 A	28-03-2001
		DE 60031615 T2	30-08-2007
		EP 1085534 A2	21-03-2001
		JP 2001154726 A	08-06-2001
		TW 484087 B	21-04-2002
		US 6446027 B1	03-09-2002
EP 1750360 A1	07-02-2007	NONE	
US 2004158428 A1	12-08-2004	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82