



(11)

EP 3 398 660 A1

(12)

EUROPEAN PATENT APPLICATION

(43) Date of publication:
07.11.2018 Bulletin 2018/45

(51) Int Cl.:
A62C 37/36 ^(2006.01) **A62C 99/00** ^(2010.01)

(21) Application number: **18169719.4**

(22) Date of filing: **27.04.2018**

(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: **Pruneri, Marco**
39044 Egna (Bolzano) (IT)

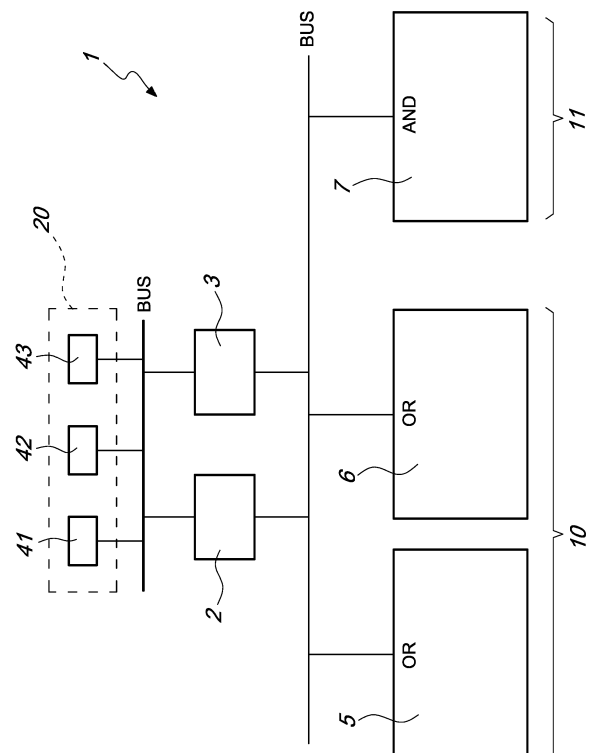
(72) Inventor: **Pruneri, Marco**
39044 Egna (Bolzano) (IT)

(74) Representative: **Forattini, Amelia**
INTERNAZIONALE BREVETTI
INGG. ZINI, MARANESI & C. S.R.L.
Piazza Castello 1
20121 MILANO (IT)

(30) Priority: **02.05.2017 IT 201700047101**

(54) **FIRE PREVENTION APPARATUS FOR CONTROLLED ATMOSPHERE ENVIRONMENTS**

(57) A fire prevention apparatus for controlled atmosphere environments, including at least two independent central control units (2,3) which control the oxygen level in one or more environments (20) to be controlled by means of a plurality of oxygen sensors (41,42,43); the sensors are connected to the central control units (2,3), which control the oxygen level in the environment (20) to be controlled and give clearance, independently of each other, for the switching on and off of a plurality of nitrogen generators (5, 6, 7); the nitrogen generators (5, 6, 7) are divided into two subsets: a first subset (10), including generators (5, 6) that are necessary and sufficient to cover 100% of the losses of the environment (20) or environments to be controlled, and a second subset (11), constituted by one or more generators (7) adapted to ensure a safety margin on the sizing of the plant.



EP 3 398 660 A1

Description

[0001] The present invention relates to a fire prevention apparatus for controlled atmosphere environments, in particular hypo-oxygenated environments.

[0002] The present invention relates in particular but not exclusively to plants for preventing fires in low oxygen and in normobaric hypoxic plants/chambers for sports, also known as "altitude simulation chambers" for personal training.

[0003] In these environments, the effect of high-altitude permanence is simulated by keeping the internal pressure equal to the external pressure and reducing the percentage of oxygen inside the environment, in order to increase the natural oxygenation capacity, resistance to prolonged efforts and accordingly the athletic performance of users.

[0004] It is known that the method for preventing fires in enclosed environments characterized by a reduced level of oxygen, with respect to the value of 20.9% that is normally present in nature, is based on reaching and maintaining inside the enclosed environments a percentage of residual oxygen that is lower than the ignition threshold for the combustion of the material to be protected.

[0005] It is in fact known that if a percentage of oxygen lower than the value of the ignition threshold of combustion of the material contained therein is maintained inside an enclosed environment, it will be impossible to set fire to the material and therefore the risk of combustion/fire of the material in the low-oxygen environment will be eliminated.

[0006] To make a numeric example: if the material to be protected inside a closed depot were paper, internationally acknowledged experimental tables of ignition thresholds prescribe keeping the oxygen level inside the depot below 14.0%, since by keeping the oxygen level below this threshold it has been demonstrated that paper physically cannot catch fire.

[0007] It is also known that inside altitude simulation chambers, where athletes/people try to reproduce on themselves the effect of high-altitude stays (in the mountains), in order to improve their own aerobic capacity, the goal is the same: to reach and maintain in an environment that is isobaric with the outside a percentage of oxygen that is lower than the 20.9% to which we are normally subjected in nature and is not harmful and/or does not entail risks for the health of the user.

[0008] In practice, reducing the level of oxygen in an environment subjected to a certain total pressure (for example the approximately 1000 mbar that are present at sea level) means reducing the partial pressure of the oxygen at that pressure. The reduction of the partial pressure of the oxygen is perceived by our body as an altitude variation; specifically, as a shift to a higher altitude.

[0009] To make a numeric example: if we wished to simulate a stay at an altitude of 3400 m while staying at sea level, we would have to lower the concentration of oxygen in an environment until it reaches 14.0%. This occurs because 140 mbar of pressure (14.0% oxygen) on 1000 mbar of atmospheric pressure at sea level are equivalent to the partial pressure of the oxygen that is present at the percentage value of 20.9% at an altitude of 3400 m.

[0010] It is also known from various medical studies and various experiments, mention is made here for example of the study by the Swiss Mountaineering Association, that the minimum level of residual oxygen that can be maintained within these enclosed environments that is not harmful or hazardous for human health for any stay time, always at 1000 mbar of total atmospheric pressure, is 11.1 %.

[0011] It is also known to use nitrogen generators in order to reduce the level of residual oxygen inside an environment and bring it to the desired concentration. The nitrogen generators can be of the most disparate technologies (for example PSA, VSA, hollow fiber membranes, and others) and, connected to the environment in which the oxygen level is to be reduced, are capable of dispensing and introducing into the environment a quantity of nitrogen that is equal to or greater than the losses of the room to be compensated.

[0012] Those losses are usually defined numerically with tests, such as for example the n50 test, in which both under pressure and under partial vacuum the flow-rate of air required to keep constant a certain and well-defined pressure difference between the inside and the outside of the environment is measured (specifically, the n50 test provides for 50 Pa of pressure differential). Those flow-rates define the average loss of the room and are used as a basis for the sizing of the nitrogen generation plant which will have to be installed in order to be able to vary and maintain a certain arbitrary oxygen value within the environment.

[0013] As is known, engineering practice suggests sizing each type of plant, and in our case we are talking about the nitrogen generation plant, with a certain safety margin.

[0014] For example, it is customary in fire prevention systems, which are safety systems, to size the nitrogen generation plant so that it is capable of delivering at least 140% of the losses of the room to be conditioned/protected.

[0015] This occurs because, on the one hand, during the life of the system it is predictable that the losses of the room to be conditioned will naturally increase as the aging of the room increases, but also because it is necessary to take into account the degradation of performance, again caused by aging, also of the nitrogen generation plant, and finally because, since it is a safety system, a certain redundancy must be programmed into the nitrogen generation plant, which is necessarily composed of multiple nitrogen generators, so that any malfunction in one of the generators does not cause an unwanted increase in the oxygen level in the conditioned room which might compromise the safety level of the entire room.

[0016] It is also known that, regardless of the type of nitrogen generator used, nitrogen generators are sized and calibrated to generate a certain quantity of nitrogen per unit time with a certain percentage of residual oxygen. To make a numeric example: a nitrogen generator can be sized to produce 100 m³/h of nitrogen with 5% residual oxygen, in the mixture that it produces/dispenses.

[0017] It is also known from physics that the percentage of oxygen that it will be possible to reach in a closed room is determined by the average of the flows entering the room: for example, if the room has losses of 100 m³/h (i.e., 100 m³/h of external air characterized by an oxygen value of 20.9% enter the room) and these 100 m³/h are compensated with a nitrogen flow of 100 m³/h with 5% residual oxygen, mathematics tells us that asymptotically the room will reach the residual oxygen concentration given by: $(5\% + 20.9\%)/2 = 12.95\%$.

[0018] The need is therefore felt to economically and safely solve the problem of sizing, controlling and ensuring the safety of these plant, minimizing the cost of redundancy.

[0019] In practice, the problem that arises in sizing is the following: how to size the nitrogen generation plant and the control system of the nitrogen generation plant so that a failure on the nitrogen generation plant or a failure on the control system do not allow the system to shift, downward or upward, from the target oxygen level and therefore still maintain the room in a safe condition at a minimal cost. In other words, a failure either in the nitrogen generation plant or in the control system of the plant should in any case allow the plant to maintain the target oxygen level without the risk of raising the oxygen level; this rise would no longer allow to ensure the level of safety with respect to the problem of fire prevention on the one hand or of uncontrolled drop of the oxygen level which, if it occurred, while maintaining the safety level with respect to the problem of fire prevention, might be a risk for the health of any operators who might enter the room being unaware of a failure of the control system; minimizing the cost of the redundancy of the plant.

[0020] In fact, while on the one hand, for the reasons cited above, there is the need to oversize the capacity of the nitrogen generation plant, it is necessary to consider on the other hand that any failure of the control system, on an oversized plant, might cause the nitrogen generation plant to generate an oversized flow with respect to the losses to be compensated of the room to be controlled. This oversized flow might bring the room to a level of oxygen that is so low that it can be a risk for the health of the people inside the room. On the other hand, if one does not choose to oversize the nitrogen generation plant, any failure of a part thereof would inevitably lead to the situation that the plant is no longer able to generate a nitrogen flow sufficient to compensate the losses of the room. In this case, the consequent increase in the level of oxygen inside the room, while not entailing a risk for the health of any people inside, will compromise the safety of the room with respect to the problem of fire prevention.

[0021] DE10235718 discloses an inertizing method for reducing fire and explosion risk in closed room, such as cold store, switching or control center, submarine, bank vault, diving bell or aircraft. The inertizing method has the oxygen level within one or more closed rooms reduced to a required oxygen level below the atmospheric oxygen level, dependent on one or more measured parameters, e.g. the gas temperature value or the humidity value in the closed room, the material composition of objects in the closed room, or the use of the closed room.

[0022] The aim of the present invention is to provide one or more controlled atmosphere environments with a correctly sized fire prevention system.

[0023] Within the scope of this aim, an object of the invention is to provide one or more controlled atmosphere environments with a fire prevention system that is redundant, operates correctly and safe, even in case of a failure of the control system or of the nitrogen generation plant.

[0024] This aim and these and other objects which will become better apparent hereinafter are achieved by a fire prevention apparatus for controlled atmosphere environments, characterized in that it comprises at least two independent central control units which control the oxygen level in one or more environments to be controlled by means of a plurality of oxygen sensors adapted to measure the oxygen present in one or more environments to be controlled; the sensors being connected to the central control units; the central control units controlling the oxygen level in the one or more environments to be controlled and giving clearance, independently of each other, for the switching on and off of a plurality of nitrogen generators; the nitrogen generators being divided into two subsets: a first subset, including generators that are necessary and sufficient to cover 100% of the losses of the one or more environments to be controlled, and a second subset, constituted by generators adapted to ensure a safety margin on the sizing of the plant.

[0025] Further characteristics and advantages will become better apparent from the description of preferred but not exclusive embodiments of the invention, illustrated by way of non-limiting example in the accompanying drawings, wherein the only figure is a block diagram of the fire prevention system according to the present invention.

[0026] With reference to the figure, the fire prevention apparatus for controlled atmosphere environments according to the invention, designated generally by the reference numeral 1, includes at least two independent central control units, designated by the reference numerals 2 and 3, which control the oxygen level in one or more environments 20 to be controlled, by virtue of the information on the oxygen level inside the environment, which is received for example from a network of oxygen sensors and/or oxygen analysis points, designated by the reference numerals 41, 42 and 43.

[0027] According to the embodiment shown in the figure, the sensors 41, 42 and 43 are arranged inside the environment to be controlled and are connected to each central control unit 2 and 3.

[0028] According to a further embodiment, not visible in the figure, the sensors 41, 42 and 43 can be arranged inside central suction units, arranged outside the environment or environments 20 to be controlled, and connected to the environment or environments 20 to be controlled by means of appropriate suction tubes.

[0029] The central control units 2 and 3 control the oxygen level, giving clearance, independently of each other, for the switching on and off of generators, designated by the reference numerals 5, 6 and 7, of the nitrogen generation plant.

[0030] The minimum number of the independent oxygen analysis points and/or oxygen sensor 41, 42, 43, inside the environment is at least equal to three for safety and redundancy reasons.

[0031] The three or more oxygen analysis points and/or sensors 41, 42, 43 are independent, i.e., they take independent measurements, and are appropriately arranged separately within the environment to be controlled, so that their arrangement allows to gather information that is as much as possible representative of the entire volume of the environment and not of a single point or location within the environment.

[0032] The nitrogen generation plant is divided into two subsets: a subset 10, constituted by the generators that are necessary and sufficient to cover 100% of the losses of the plant, and a subset 11, constituted by the generators installed to ensure a safety margin on the sizing of the apparatus.

[0033] According to this concept, the nitrogen generation apparatus is constituted by a minimum number of three nitrogen generators, designated by the reference numerals 5, 6 and 7, each of which preferably but not necessarily has a capacity that is equivalent and/or similar to the others.

[0034] The nitrogen generators 5, 6, 7 can be operated independently of each other.

[0035] The nitrogen generation plant is sized so that the plant provides at least one generator to cover the safety margin of the plant itself (aging, failure of a single nitrogen generator, etc.).

[0036] The control logic of the generators is of the "OR" type for the generators that belong to the subset 10; i.e., for the number of generators the sum of capacities of which is the minimum capacity for covering the losses of the environment.

[0037] OR logic states that if at least one of the central control units gives clearance for the switch-on of the generator to be controlled in OR logic, the generator is activated.

[0038] The remaining number of generators, which are part of the subset 11, the sum of capacities of which represents the surplus capacity of the system, i.e., the capacity that during design is the embodiment of the safety factor of the plant, is controlled with "AND" logic, i.e., all the central control units 2, 3 give command/clearance for the switching on of a nitrogen generator so that the generator actually begins to operate and to dispense nitrogen.

[0039] The embodiment of the apparatus described above allows to obtain a redundant system which operates correctly and is safe even in case of a failure of the control system or of the nitrogen generation plant.

[0040] If in fact one of the central control units 2, 3 fails, in the worst case it might command the switching on of the individual nitrogen generators in inverted logic with respect to the actual needs.

[0041] This would lead to the following table of possible states of control of the plant during the failure:

Central control units	Command ON (status A)	Y Command OFF (status B)
Control unit 3 operating	ON	OFF
Control unit 2 failed	OFF	ON

[0042] In relation to two statuses (status A and status B), one would obtain the following switch-on table of the two subsets of nitrogen generators 10, 11:

Control status	Switch-on status of N2 generator subset (10)	Switch-on status of N2 generator subset (11)
Status A	ON	OFF
Status B	ON	OFF

[0043] This clearly shows that in a situation of failure of one of the central control units the nitrogen generators in any case would deliver only the flow-rate required and sufficient to cover the natural losses of the room.

[0044] For this reason, the oxygen level calculated during design would be maintained even in case of failure of one of the central control units 2, 3.

[0045] In case instead of a failure of one of the nitrogen generators in the subset 10 or in the subset 11, in any case the other generators that are present in the nitrogen generation plant, despite not being able to ensure the safety margin of the plant, would be able to ensure the minimum necessary flow of nitrogen to compensate for the failed generator and maintain the oxygen level at the desired level.

[0046] In practice it has been found that the invention achieves the intended aim and objects, a fire prevention apparatus having been provided which is capable of ensuring inherent safety for people and objects in low-oxygen controlled atmosphere plants.

[0047] The apparatus according to the present invention is based on the concept of redundancy of the control system. The condition of redundancy requires at least two independent central control units which control the oxygen level in the room or rooms to be controlled by virtue of the information on the oxygen level within the room/rooms, which is received for example from a network of oxygen sensors and oxygen analysis points which are inside the room and are connected to a central suction and analysis unit.

[0048] The central control units therefore control the oxygen level, giving clearance to the switching on and off of the various generators of the nitrogen generation plant independently of each other.

[0049] The materials used, as well as the dimensions, may of course be any according to the requirements and the state of the art.

Claims

1. A fire prevention apparatus for controlled atmosphere environments, **characterized in that** it comprises at least two independent central control units (2, 3) which control the oxygen level in one or more environments (20) to be controlled by means of a plurality of oxygen sensors (41, 42, 43) adapted to measure the oxygen present in one or more environments (20) to be controlled; said sensors (41, 42, 43) being connected to said central control units (2, 3); said central control units (2, 3) controlling the oxygen level in said one or more environments (20) to be controlled and giving clearance, independently of each other, for the switching on and off of a plurality of nitrogen generators (5, 6, 7); said nitrogen generators (5, 6, 7) being divided into two subsets: a first subset (10), comprising generators (5, 6) that are necessary and sufficient to cover 100% of the losses of said one or more environments to be controlled, and a second subset (11), constituted by generators (7) adapted to ensure a safety margin on the sizing of said plant.
2. The apparatus according to claim 1, **characterized in that** it comprises at least three oxygen sensors (41, 42, 43); said sensors (41, 42, 43) performing independent measurements and being arranged separately inside said environment (20) to be controlled, so that their arrangement allows to gather information that is as representative as possible of the entire volume of the environment and not of a single point or location inside said environment (20).
3. The apparatus according to claim 2, **characterized in that** it comprises at least three nitrogen generators (5, 6, 7) which can be operated independently of each other; at least one (7) of said nitrogen generators being adapted to cover the safety margin of said plant.
4. The apparatus according to claim 3, **characterized in that** two nitrogen generators (5, 6) are part of said first subset (10) and the sum of the capacities of said two generators (5, 6) is at least equal to the minimum capacity required to cover the losses of the environment (20); if at least one of said central control units (2, 3) gives clearance for the switch-on of one of said generators (5, 6), said generator (5, 6) is activated.
5. The apparatus according to claim 4, **characterized in that** at least one third generator (7) is part of said second subset (11) and its capacity represents the surplus capacity of the system, i.e., the capacity that in the design represents the embodiment of the safety factor of the apparatus; said at least one generator (7) of said second subset (11) being controlled by all of said central control units (2, 3).
6. The apparatus according to one or more of the preceding claims, **characterized in that** in case of failure of one of said central control units (2, 3), in any case said nitrogen generators (5, 6, 7) deliver only the flow rate required and sufficient to cover the natural losses of said one or more environments (20); even in case of failure of one of said central control units (2, 3), a desired level of oxygen is maintained.
7. The apparatus according to one or more of the preceding claims, **characterized in that** in case of failure of one of said nitrogen generators (5, 6, 7), of said first subset (10) or of said second subset (11), the other nitrogen generators (5, 6, 7) still ensure the minimum nitrogen flow required to compensate for the failed generator and maintain the oxygen level at the desired level.
8. The apparatus according to claim 1, **characterized in that** it comprises at least three oxygen sensors (41, 42, 43); said sensors (41, 42, 43) being arranged within central suction units, said central suction units being connected to said environment or environments (20) to be controlled by means of suction tubes; said suction tubes being connected

to sampling points which are arranged separately within said environment (20) to be controlled, so that their arrangement allows to gather information that is as representative as possible of the entire volume of said environment or environments (20) and not of a single point or location within said environment or environment (20); said sensors (41, 42, 43) performing independent measurements.

5

10

15

20

25

30

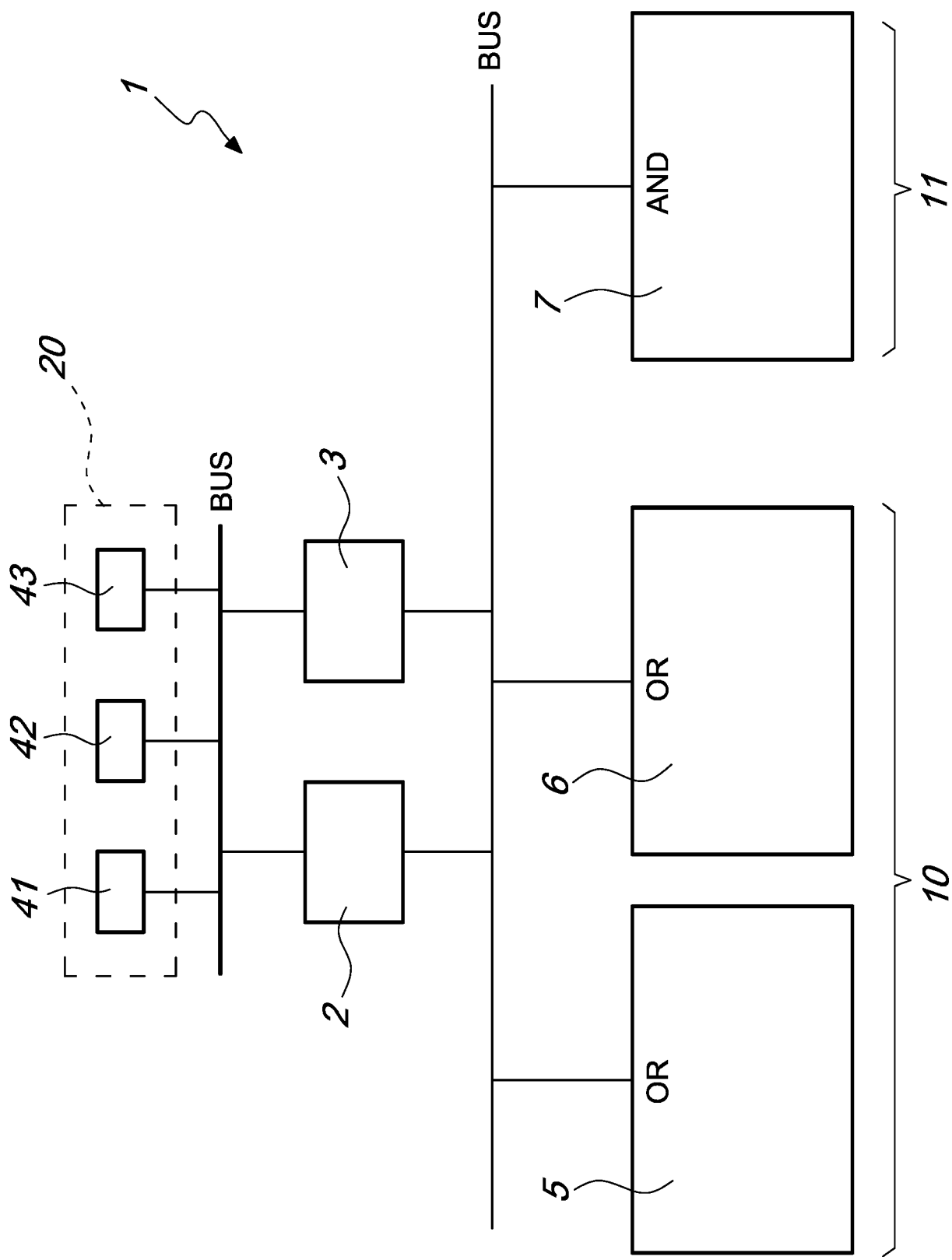
35

40

45

50

55





EUROPEAN SEARCH REPORT

Application Number
EP 18 16 9719

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 102 35 718 B3 (HTK HAMBURG GMBH [DE]) 8 April 2004 (2004-04-08) * paragraph [0022] - paragraph [0028] * * figures * -----	1-8	INV. A62C37/36 A62C99/00
			TECHNICAL FIELDS SEARCHED (IPC)
			A62C
The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 11 September 2018	Examiner Nehrdich, Martin
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 03/02 (P04C01)

11-09-2018

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
DE 10235718	B3	08-04-2004	NONE

EPO FORM P0459

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

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

- DE 10235718 [0021]