



(51) International Patent Classification:

A62B 7/14 (2006.01) A62B 9/02 (2006.01)
A62B 9/00 (2006.01) B64D 10/00 (2006.01)

(21) International Application Number:

PCT/IB2011/000781

(22) International Filing Date:

28 February 2011 (28.02.2011)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

61/308,476 26 February 2010 (26.02.2010) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— of inventorship (Rule 4.17(iv))

Published:

— with international search report (Art. 21(3))

— before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))

(54) Title: METHOD FOR DETERMINING PARTIAL PRESSURE OF A GASEOUS CONSTITUENT AND REGULATOR OF BREATHING MASK FOR AIRCRAFT OCCUPANT

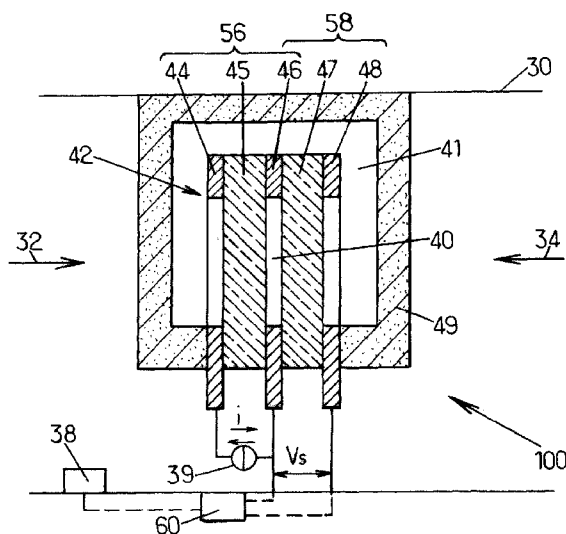


FIG. 9.

(57) Abstract: A method for determining a characteristic such as partial pressure or percentage of a gaseous constituent in a first gas mixture flow (32) in a flow chamber (30) where flows alternatively said first gas mixture flow (32) and a second gas mixture flow (34) comprising the following steps: a) introducing the first gas mixture flow (32) into a sensing chamber (40) when the first gas mixture flow (32) flows in the flow chamber (30), b) preventing introduction of gas from the flow chamber (30) into the sensing chamber (40) at least when the second gas mixture flow (34) flows in the flow chamber (30), c) sensing said characteristic of the first gas mixture flow (32) in the sensing chamber (40).

**Method for determining partial pressure of a gaseous constituent and
regulator of breathing mask for aircraft occupant**

Field of the invention

The present invention relates to a method for determining a
5 characteristic such as partial pressure or percentage of a gaseous constituent
and a regulator of breathing mask for aircraft occupant. The gaseous
constituent is in particular oxygen or carbon dioxide.

Background of the invention

The partial pressure or percentage of oxygen (and carbon dioxide)
10 are particularly useful in order to satisfy the needs of the user while reducing
the consumption in pure oxygen (provided by an oxygen cylinder, a chemical
generator or a liquid oxygen converter) or gas highly enriched in oxygen
provided in particular by an on-board oxygen generator system (OBOGS).

But, when two gases having different mixtures successively flow in
15 opposite directions in a chamber, the measurement of a characteristic of a
gaseous constituent in the first gas mixture flow is disturbed by the second gas
mixture. The invention aims at reducing this problem.

Summary of the invention

For this purpose the invention provides a method for determining a
20 characteristic such as partial pressure or percentage of a gaseous constituent
in a first gas mixture flow in a flow chamber where flows alternatively said first
gas mixture flow and a second gas mixture flow in opposite directions
comprising the following steps:

a) introducing the first gas mixture flow into a sensing chamber when
25 the first gas mixture flow flows in the flow chamber,

b) preventing introduction of gas from the flow chamber into the
sensing chamber at least when the second gas mixture flow flows in the flow
chamber,

c) sensing said characteristic of the first gas mixture flow in the
30 sensing chamber.

According to another feature in accordance with the invention, preferably the method further has the following steps:

- providing a user with a breathing mask for aircraft occupant including a demand regulator,
- 5 – generating a respiratory gas flow by breathing in of the user into the flow chamber, and
- generating an exhalation gas flow by breathing out of the user into the flow chamber, one amongst the respiratory gas flow and the exhalation gas flow being the first gas mixture flow and the other being the second gas mixture
- 10 flow.

According to a supplementary feature in accordance with the invention, preferably the method further has the following steps:

- splitting the flow chamber in a respiratory chamber and sensing chamber,
- 15 – inserting an isolation valve between the sensing chamber and the respiratory chamber, in order to prevent introduction of the second gas mixture flow into the sensing chamber,
- generating the first gas mixture flow into the respiratory chamber, by breathing of the user into the respiratory chamber.

- 20 According to a supplementary feature in accordance with the invention, preferably the method further comprising feeding the respiratory chamber with the first gas mixture flow through the sensing chamber and the isolation valve.

25 According to an alternative feature in accordance with the invention, preferably the method comprising feeding sensing chamber with the first gas mixture flow through the respiratory chamber and the isolation valve.

 According to another feature in accordance with the invention, preferably the method further comprises introducing the first gas mixture flow into the sensing chamber from the flow chamber during step a).

- 30 According to a supplementary feature in accordance with the invention, preferably the method further comprises:

d) detecting the occurrence of the first gas mixture flow in the flow chamber,

- during step a), putting the sensing chamber in flow communication with the flow chamber when the occurrence of the first gas mixture flow in the flow chamber is detected.

According to another supplementary feature in accordance with the invention, preferably the method further comprises preventing communication between the flow chamber and the sensing chamber when the occurrence of the first gas mixture flow in the flow chamber is not detected.

10 According to another feature in accordance with the invention, preferably the method further comprises:

- placing a solid ionic conductor of a pump electrochemical cell interposed between the flow chamber and the sensing chamber, and
- during step a), pumping said gas constituent from the flow chamber into the sensing chamber through the solid ionic conductor.

Otherwise, the invention provides a method for protecting aircraft occupant comprising the steps of:

- a) providing a user with a breathing mask for aircraft occupant,
- b) providing a respiratory gas including a mixture of breathable gas and dilution gas to the user,
- c) sensing partial pressure or percentage of oxygen or carbon dioxide in exhalation gas flow generated by the user,
- d) adjusting the rate of oxygen or breathable gas in the respiratory flow in accordance with the partial pressure or percentage of oxygen or carbon dioxide.

It appears that the partial pressure or percentage of oxygen or carbon dioxide in exhalation gas flow is an efficient indication concerning the oxygen need of user. Therefore, the consumption in oxygen can be accurately adjusted.

30 The invention also provides a breathing mask for aircraft occupant including a demand regulator, said regulator comprising:

– a breathable gas supply line to be connected to a source of breathable gas and supplying a flow chamber with breathable gas,

– a dilution gas supply line to be connected to a source of dilution gas and supplying the flow chamber with dilution gas,

5 – a dilution adjusting device adjusting the rate of dilution gas in the respiratory gas supplied to the flow chamber, the dilution adjusting device comprising a dilution valve and a control device controlling the dilution valve in accordance with a dilution signal generated by the gas sensor in function of the partial pressure or percentage of oxygen or carbon dioxide in exhalation gas.

10 In advantageous embodiments, the breathing assembly preferably further has one or more of the following features:

Brief description of the drawings

Other features and advantages of the present invention will appear in the following detailed description, with reference to the appended drawings in
15 which:

– Figure 1 shows a breathing mask comprising a flow chamber,

– Figure 2 schematically represents a first flow and a second flow in the flow chamber of the breathing mask, according to a sensing device not within the scope of the invention,

20 – Figure 3 represents variations of the first flow in the flow chamber during the time,

– Figure 4 represents variations of the second flow in the flow chamber during the time,

25 – Figure 5 represents measurements provided by gas sensors placed in the flow chamber,

– Figure 6 represents a first embodiment of a sensing device in accordance with the invention,

– Figure 7 represents a second embodiment of a sensing device in accordance with the invention,

30 – Figure 8 represents a third embodiment of a sensing device in accordance with the invention,

– Figure 9 represents a fourth embodiment of a sensing device in accordance with the invention,

– Figure 10 represents a step of a method according to the invention using the sensing device of the fourth embodiment,

5 – Figure 11 is a flowchart representing different steps according to the invention,

– Figure 12 represents a method according to the invention,

– Figure 13 represents a variation of the method represented in figure 12.

10 Detailed description of the invention

Figure 1 discloses main functions of a breathing mask 4 for occupant of an aircraft, in particular for pilot disposed in a cabin 10 of an aircraft.

The breathing mask 4 comprises a demand regulator 1 and an oronasal face piece 3 fixed to a tubular connecting portion 5 of the regulator 1.

15 When a user 7 dons the breathing mask 4, the oronasal face piece 3 is put to the skin of the user face 7 and delimits a respiratory chamber 9.

The demand regulator 1 has a casing 2 including a breathable gas supply line 12, a dilution gas supply line 14 and a respiratory gas supply line 16. The respiratory gas supply line 16 has a downstream end in fluid
20 communication with the respiratory chamber 9.

The breathable gas supply line 12 is supplied at its upstream end with pressurized oxygen by a source of breathable gas 8 through a feeding duct 6. In the embodiment shown, the pressurized source of breathable gas 8 is a cylinder containing pressurized oxygen. The breathable gas supply line 12
25 supplies the respiratory chamber 9 with breathable gas through the respiratory gas supply line 16, the downstream end of the breathable gas supply line 12 being directly in fluid communication with the upstream end of the respiratory gas supply line 16.

The dilution gas supply line 14 is in communication by its upstream
30 end with a source of dilution gas. In the illustrated embodiment, the dilution gas is air and the source of dilution gas is the cabin 10 of the aircraft. The dilution gas supply line 14 supplies the respiratory chamber 9 with dilution gas through

the respiratory gas supply line 16, the downstream end of the dilution gas supply line 14 being directly in fluid communication with the upstream end of the respiratory gas supply line 16. So, in the embodiment illustrated, the breathable gas and the dilution gas are mixed in the respiratory gas supply line 16 of the casing 2, i.e. before supplying the respiratory chamber 9 through the tubular connecting portion 5. Therefore a flow 62 of respiratory gas flows in the respiratory gas supply line 16 and the respiratory chamber 9, the respiratory gas including breathable gas and dilution gas mixed.

The regulator 1 further comprises an exhaust line 18 and an exhaust valve 20. The exhaust valve 20 is disposed between the downstream end of the exhaust line 18 and the cabin 10 (ambient air). The upstream end of the exhaust line 18 is in communication with the respiratory chamber 9 of the oronasal face piece 3 through the tubular connecting portion 5 and receives a flow 64 of gas exhaled by the user. Concerning the exhaust of the exhalation gas flow 64, the exhaust valve 20 functions as a check valve which opens under the pressure of the exhalation gas flow 64 and closes for preventing air of the cabin 10 from entering into the flow chamber 30.

The user 7 breathes in and breathes out in the respiratory chamber 9. The exhalation line 18 is in communication directly or through the respiratory chamber 9 with the respiratory gas supply line 16. Therefore, the gas supply line 16, the respiratory chamber 9 and the exhalation line 18 define a flow chamber 30 without separation.

The demand regulator 1 further has a pressure adjusting device 22 and a dilution adjusting device 24.

The pressure adjusting device 22 adjusts the pressure in the flow chamber 30 and in particular in the respiratory chamber 9. In the embodiment illustrated, the pressure adjusting device 22 comprises in particular a main valve disposed between the feeding duct 6 and the respiratory gas supply line 16.

The dilution adjusting device 24 adjusts the rate of oxygen in the respiratory gas flow 62. In the embodiment illustrated, the dilution adjusting device comprises in particular a dilution valve 23 and a control device 60. The

dilution valve 23 is disposed between the dilution gas supply line 14 and the respiratory gas supply line 16. The control device 60 controls the dilution valve 23.

Demand regulator starts supplying first gas mixture (respiratory gas) in response to the user of the breathing mask breathing in and stops supplying respiratory gas when the user stops breathing in.

One can refers to prior art, such as for example to document US 6,789,539 for a more detailed description of a demand regulator. The present invention is also applicable to other types of dilution adjusting device 24, such as the dilution adjusting device disclosed in patent application PCT/FR2011/050359 or US 6,789,539 included by reference.

Figure 2 schematically represents the flow chamber 30 in which alternatively flows a first gas mixture flow 32 and a second gas mixture flow 34. In order to adjust the rate of oxygen to deliver to the user 7, a characteristic (in particular the partial pressure or percentage of a gaseous) of a gaseous constituent (in particular oxygen or carbon dioxide) of the first gas mixture flow 32 is to be detected by a gas sensor 42.

The first gas mixture flow 32 may be either the respiratory gas flow 62 or the exhalation gas flow 64, which means that the characteristic of the gaseous constituent to sense may be either in the respiratory gas or in the exhalation gas. So, the first gas mixture flow 32 flows from the tubular connecting portion 5 to (the mouth or nose of) the user 7 or from the user 7 to the tubular connecting portion 5. Conversely, the second gas mixture flow 34 may be either the exhalation gas flow 64 or the respiratory gas flow 62.

As represented schematically in figure 3, between the time 0 and the time T_1 , the gas content in the flow chamber 30 reaches the gas content of the first gas mixture flow 32 and then between the time T_1 and the time $T_1 + T_2$, the first gas mixture flow 32 becomes absent from the flow chamber 30.

As represented schematically in figure 4, between the time 0 and the time T_1 , the second gas mixture flow 34 becomes absent from the flow chamber 30 and then, between the time T_1 and the time $T_1 + T_2$, the gas

content in the flow chamber 30 reaches the gas content of the second gas mixture flow 34.

It should be noticed that in figures 3 and 4 the time for filling the flow chamber 30 is neglected.

5 So, it may be considered by simplification that succesiveley during a T_1 period the first gas mixture flow 32 flows in the flow chamber 30 in a first direction, then during a T_2 period the second gas mixture flow 34 flows into the flow chamber 30 in a second direction opposite to the first direction, then the first gas mixture flow 32 flows again in the flow chamber 30 during another T_1 period, and so on. The T_1 period may be considered as equal to the T_2 period, and called T .

15 The gaseous content of the first gas mixture flow 32 being different from the second gas mixture flow 34, the second gas mixture flow 34 disturbs the measurment of the characteristic of the gaseous content of the first gas mixture flow 32. It should be understood that the first gas mixture and the second gas mixture may content the same constituents (at least some identical constituents), and only differ in the percentage of some of the constituents (in particular percentage of oxygen, carbon dioxide and steam).

20 Figure 5 presents three measurements 42a, 42b, 42c provided by gas sensors 42 having different response times T_r for the above described example. The measurements 42a, 42b, 42c correspond to gas sensors having a response time respectively equal to $T/10$, $T/2$ and $2T$.

25 It appears that the gas sensor providing measurements 42a, 42b are suitable for the present example, wheras the gas sensor providing measurement 42c is not appropriate.

30 So, the shorter the response time of the gas sensor is, the more accurate the measurment is. But, a sensor with a short time response is generally more expensive than a sensor with a longer time response, and sometimes a sensor with a time response satisfying for a particular application does not exist.

Figure 6 represents a first embodiment of a device 100 in accordance with the invention. The device 100 is a portion of the breathing mask 4 represented in figure 1.

The device 100 comprises a flow direction sensor 38, a shutter 50, a driving device 51 and a gas sensor 42 placed in a sensing chamber 40 in fluid communication with the flow chamber 30 through a passage 66.

The flow direction sensor 38 and the gas sensor 42 are connected to the control device 60. The flow direction sensor 38 detects if the flow direction in the flow chamber 30 corresponds to the direction of the first flow mixture 32. In variant, the flow direction sensor 38 may detect if the flow direction in the flow chamber 30 corresponds to the direction of the second flow mixture 34.

The shutter 50 is movable between an active position in which it closes the passage 66 and an inactive position in which it is away from the passage 66.

The control device 60 controls the driving device 51 in order to place the shutter 50 in open position when the flow direction sensor 38 detects the first gas flow 32, so that the first gas mixture flow 32 (partially) enters in the sensing chamber 40. Moreover, the control device 60 controls the driving device 51 in order to place the shutter 50 in closed position when the flow direction sensor 38 does not detect the the first gas flow 32, so that the second the second gas mixture flow 34 is prevented from entering in the sensing chamber 40.

Therefore, the sensing chamber 40 contains only gas mixture of the first gas mixture flow 32 at any time. So, the gas sensor 42 transmits a dilution signal which accuracy is not influenced by the second gas mixture flow 34. The control device 60 controls the dilution valve 24 in accordance with the dilution signal generated by the gas sensor 42.

The gas sensor 42 is adapted to determine in particular partial pressure (or percentage) in oxygen (or carbon dioxide) of the gas contained in the sensing chamber 40.

The flow direction sensor 38 includes in particular a pressure sensor, a pressure gauge sensor, a pressure differential sensor, thermistances, a

sensor of the state of a check valve or a piezo sensor device comprising a flexible sheet and detecting the direction of the curvature of the flexible sheet.

Figure 7 represents a second embodiment of a device 100 in accordance with the invention.

5 In this second embodiment, the characteristic of the gaseous constituent to sense is in the respiratory gas, so that the first gas mixture flow 32 is the respiratory gas flow 62 and the second gas mixture flow 34 is the exhalation gas flow 64.

10 An isolation valve 36 is inserted between the respiratory gas supply line 16 and the respiratory chamber 9. The gas sensor 42, in connection with the control device 60, is placed in the respiratory chamber 16 which forms the sensing chamber 40. The isolation valve 36 prevents gas from entering into the sensing chamber 16, 40 from the respiratory chamber 9.

In the embodiment illustrated, the isolation valve 36 is a check valve.
15 In variant, it may be an inspiration valve similar to the exhaust valve 20.

Figure 8 represents a third embodiment of a device 100 in accordance with the invention.

In this third embodiment, the characteristic of the gaseous constituent to sense is in the exhalation gas, so that the first gas mixture flow
20 32 is the exhalation gas flow 64 and the second gas mixture flow 34 is the respiratory gas flow 62.

The isolation valve 36 is inserted between the respiratory chamber 9 and the exhalation line 18. The gas sensor 42, in connection with the control device 60, is placed in the exhalation line 18 which forms the sensing chamber
25 40. The isolation valve 36 prevents gas from entering into the respiratory chamber 9 from the exhalation line 18.

Figure 9 represents a fourth embodiment of a device 100 in accordance with the invention.

30 The gas detector 42 comprises a pumping plate 44, a first disk of solid ionic conductor 45, a common plate 46, a second disk of solid ionic conductor 47 and a sensing plate 48.

The pumping plate 44, the common plate 46 and the sensing plate 48 are electrodes preferably made of platinum films.

The pumping plate 44, the common plate 46 and the sensing plate 48 are of substantially annular form. Therefore, the sensing chamber 40 is delimited by the common plate 46, the first ionic conductor 45 and the second ionic conductor 47.

A current source 39 is inserted between the pumping plate 44 and the common plate 46. The common plate 46 and the sensing plate 48 are connected to the control device 60, as well as the flow direction sensor 38.

The pumping plate 44, the first solid ionic conductor 45 and the common plate 46 define a pumping electrochemical cell 56. The common plate 46, the second solid ionic conductor 47 and the sensing plate 48 define a sensing electrochemical cell 58.

The ionic conductors 45, 47 define solid electrolyte. They are preferably made in dioxide zirconium suitably adapted for the conduction of ions of oxygen O_2 .

The gas sensor 42 further comprises an optional filter 49 surrounding the pumping electrochemical cell 56 and the sensing electrochemical cell 58. The filter 49 prevents particles from entering into the sensor 42. Therefore, the gas sensor 42 includes a buffer chamber 41 extending between the flow chamber 30 and the pumping electrochemical cell 56 (and the sensing electrochemical cell 58).

The gas sensor 42 may be placed either in the respiratory chamber 9, in the respiratory gas supply line 16 or in the exhalation line 18, and of any of the first to third embodiment described above.

As illustrated in figure 10, when the electrical power supply 39 outputs a pumping current i at the value I_p , oxygen ions are transported through the ionic conductors 45 from the sensing chamber 40 to the buffer chamber 41. Therefore, an evacuation phase 28 corresponds to a phase of pumping current i equal to I_p . So, the partial pressure in Oxygen PO_2 in the sensing chamber 40 decreases. The voltage V_s between the sensing plate 48 and the common plate, called Nerst voltage, increases.

When the electrical power supply 39 outputs a pumping current i at the value $-I_p$, oxygen ions are transported through the ionic conductor 45 from the buffer chamber 41 to the sensing chamber 40. Therefore, a pressurisation phase 26 corresponds to a phase of pumping current i equal to $-I_p$. So, the partial pressure in Oxygen PO_2 in the sensing chamber 40 increases and the Nerst voltage V_s between the sensing plate 48 and the common plate 46 decreases.

In operation, the control device 60 causes a repetitive sequence where the oxygen pumping current I is successively reversed to maintain the Nerst voltage V_s between to predetermined values V_1 , V_2 .

Therefore, the partial pressure of Oxygen in the sensing chamber 40 varies between two values PO_{2low} and PO_{2high} .

The period of oscillation T_p is proportional to the oxygen partial pressure in the buffer chamber 41. Therefore, period of the pumping cycle is used to determine the ambient oxygen partial pressure.

The transportation of the oxygen through the ionic conductor 45 during the pressurisation phase 26 creates a pressure drop in the buffer chamber 41. The low porosity of the external filter 49 limits the entry of the ambient gas into the sensor and is responsible of the main delay (high response time) in the oxygen partial pressure measurement.

The response time of the gas sensor 42 generates an error in the measurement of the oxygen partial pressure in the first gas mixture flow 32, due to the second gas mixture flow 34.

As shown in figure 11, in order to limit the error in the measurement of the oxygen partial pressure in the first gas mixture flow 32, the direction of the flow in the flow chamber 30 is sensed by the direction gas sensor 38. During step S38, based on the signal provided by the flow direction sensor 38, the control device 60 determines if the flow in the flow chamber 30 is in the direction of the first gas mixture flow 32. If Yes, during a measurement period 52, the pressurization phase 26 and the evacuation phase 28 repetitively and alternatively follows one another. If No, as shown in figure 12, during a period without measurement 54, the pressurisation of the sensing chamber 40 is

stopped, no pressurisation phase 26 occurring during the period without measurement 54. Consequently, diffusion of the second gas mixture flow 34 into the gas sensor buffer 41 is reduced and the sensing accuracy of the gas sensor 42 is improved. For example, the gas sensor measurement process is
5 active during inspiration of the user and stopped during exhalation of the user if the characteristic of the gaseous component to be sensed is in the respiratory gas.

In a variant shown in figure 13, during the period without measurement 54, preferably at the beginning, an evacuation phase 28 is
10 achieved. During the evacuation phase 28 of the period without measurement 54, as shown in figure 13, the pumping current i is preferably lower than during the evacuation phase 28 of the measurement period 52, i.e. lower than I_p . Therefore, the evacuation phase 28 of the period without measurement 54 lasts
15 during all the period without measurement 54 or at least more than half of the period without measurement 54.

CLAIMS

1. A method for determining a characteristic such as partial pressure or percentage of a gaseous constituent in a first gas mixture flow (32) in a flow chamber (30) where flows alternatively said first gas mixture flow (32) and a
5 second gas mixture flow (34) in opposite directions comprising the following steps:

a) introducing the first gas mixture flow (32) into a sensing chamber (40) when the first gas mixture flow (32) flows in the flow chamber (30),

b) preventing introduction of gas from the flow chamber (30) into the
10 sensing chamber (40) at least when the second gas mixture flow (34) flows in the flow chamber (30),

c) sensing said characteristic of the first gas mixture flow (32) in the sensing chamber (40).

2. The method according to claim 1 including the step of:

15 – providing a user (7) with a breathing mask (4) for aircraft occupant including a demand regulator (1),

– generating a respiratory gas flow (62) by breathing in of the user (7) into the flow chamber (30), and

– generating an exhalation gas flow (64) by breathing out of the user
20 (7) into the flow chamber (30), one amongst the respiratory gas flow (62) and the exhalation gas flow (64) being the first gas mixture flow (32) and the other being the second gas mixture flow (34).

3. The method according to the claim 2, comprising:

– splitting the flow chamber (30) in a respiratory chamber (9) and
25 sensing chamber (40),

– inserting an isolation valve (36) between the sensing chamber (40) and the respiratory chamber (9), in order to prevent introduction of the second gas mixture flow (34) into the sensing chamber (40),

– generating the first gas mixture flow (32) into the respiratory
30 chamber (9), by breathing of the user (7) into the respiratory chamber (9).

4. The method according to the claim 3, further comprising feeding the respiratory chamber (9) with the first gas mixture flow (32) through the sensing chamber (40) and the isolation valve (36).

5 5. The method according to the claim 3, further comprising feeding sensing chamber (40) with the first gas mixture flow (32) through the respiratory chamber (9) and the isolation valve (36).

6. Method according to any of claims 1 to 2, comprising introducing the first gas mixture flow (32) into the sensing chamber (40) from the flow chamber (30) during step a).

10 7. The method according to the claim 6 further comprising:

d) detecting (38) the occurrence of the first gas mixture flow (32) in the flow chamber (30),

– during step a), putting the sensing chamber (40) in flow communication with the flow chamber (30) when the occurrence (52) of the first gas mixture flow (32) in the flow chamber (30) is detected.

8. The method according to the claim 7 further comprising preventing communication between the flow chamber (30) and the sensing chamber (40) when the occurrence (54) of the first gas mixture flow (32) in the flow chamber (30) is not detected.

20 9. The method according to any of claims 7 or 8, further comprising:

– placing a solid ionic conductor (45) of a pump electrochemical cell (56) interposed between the flow chamber (30) and the sensing chamber (40), and

– during step a), pumping (26) said gas constituent from the flow chamber (30) into the sensing chamber (40) through the solid ionic conductor (45).

10. The method according to the claim 9 wherein pumping (26) is stopped during step b).

30 11. The method according to the claim 9 further comprising pumping (28) said gas constituent from the sensing chamber (40) into the flow chamber (30) through the solid ionic conductor (45) during step b).

12. The method according to any of claims 9 to 11 wherein a buffer chamber (41) is interposed between the flow chamber (30) and the pump electrochemical cell (56), and the buffer chamber (40) communicates with the flow chamber (30) through a filter (49) in (low) porous material.

5 13. The method according to any of the preceding claims comprising sensing partial pressure or percentage of a constituent in the first gas mixture flow (32) during step c).

14. The method according to the claim 13 comprising sensing partial pressure or percentage of oxygen in the first gas mixture flow (32) during step
10 c).

15. A method for regulating the rate of oxygen in respiratory gas (62) provided by a breathing mask (4) to an aircraft occupant (7) comprising the steps of the method according to any of claims 2 to 14, further comprising

- generating the first gas mixture flow (32) by mixing a pressurised
15 breathable gas (8, 12) with a dilution gas (10, 14), and
- adjusting (60) the rate of dilution gas in the respiratory flow (62) in accordance with the characteristic of the first gas mixture flow (32).

16. A sensing device for determining a characteristic such as partial pressure or percentage of a gaseous constituent comprising:

- 20 – a flow chamber (30),
- a sensing chamber (40) in fluid communication with the flow chamber (30),
- a gas sensor (42) placed in the sensing chamber (40) and adapted to sense a characteristic such as partial pressure or percentage of a
25 gaseous constituent,
- a selective device (36, 38, 50, 51, 42) isolating the sensing chamber (40) at least when gas flows in a first direction (32) in the flow chamber (30) and allowing insertion of gas when gas flows in a second direction (34) opposite to the first direction (32) in the flow chamber (30).

30 17. A regulator (1) of breathing mask (4) for aircraft occupant (7) comprising the device according to the claim 16 wherein the flow chamber (30)

is adapted to provide a respiratory gas to the aircraft occupant (7) and the regulator further comprises:

- a breathable gas supply line (12) to be connected to a source of breathable gas (8) and supplying the flow chamber (30) with breathable gas,
- 5 – a dilution gas supply line (14) to be connected to a source of dilution gas (10) and supplying the flow chamber (30) with dilution gas,
- a dilution adjusting device (24, 38, 42, 60) adjusting the rate of dilution gas in the respiratory gas (62) supplied to the flow chamber (30), the dilution adjusting device comprising a dilution valve (24) and a control device
- 10 (60) controlling the dilution valve (24) in accordance with a dilution signal generated by the gas sensor (42) in function of said characteristic.

18. A regulator according to the claim 17 further comprising a shutter (50) movable between an active position in which it prevents fluid communication from the flow chamber (30) to the sensing chamber (40) and an

15 inactive position in which it allows fluid communication from the sensing chamber (40) to the flow chamber (30).

19. A regulator according to the claim 18 further comprising a flow direction sensor (38) adapted to detect a first gas flow (32) in a first direction and/or a second gas flow (34) in a second direction opposite to the first

20 direction, the control device (60) placing the shutter (50) in inactive position when the flow direction sensor (38) detects the first gas flow (32) and in active position when the flow direction sensor (38) does not detect the the first gas flow (32).

20. A regulator according to the claim 17 wherein:

- 25 – the flow chamber (30) includes a respiratory chamber (9) and the sensing chamber (16, 40),
- the sensing chamber (16, 40) is connected:
 - upstream to the breathable gas supply line (12) and dilution gas supply line (14), and
 - 30 • downstream to the respiratory chamber (9),
- the selective device includes an isolation valve (36) interposed between the sensing chamber (16, 40) and the respiratory chamber (9), the

isolation valve (36) preventing gas from entering into the sensing chamber (16, 40) from the respiratory chamber (9).

21. A regulator according to the claim 17 wherein:

- the flow chamber (30) includes a respiratory chamber (9) and the
5 sensing chamber (18, 40),
- the sensing chamber (18, 40) is connected:
 - upstream to the respiratory chamber (9), and
 - downstream to ambient air (10) through an exhalation valve (20),
- 10 – the regulator (1) further has an isolation valve (36) interposed between the respiratory chamber (9) and the sensing chamber (18, 40), the isolation valve (36) preventing gas from entering into the respiratory chamber (9) from the sensing chamber (18, 40).

22. A regulator according to the claim 17 further comprising:

- 15 – a solid ionic conductor (45) of a pump electrochemical cell (56) interposed between the flow chamber (30) and the sensing chamber (40), and
- electrical power adapted to alternatively pump (26) a gas constituent from the flow chamber (30) into the sensing chamber (40) through the solid ionic conductor (45) and from the sensing chamber (40) into the flow
20 chamber (30) through the solid ionic conductor (45).

23. A regulator according to the claim 22 wherein a buffer chamber (41) is interposed between the sensing chamber (40) and the flow chamber (30), and the buffer chamber (40) communicates with the flow chamber (30) through a filter (49) in (low) porous material.

- 25 24. A method for protecting aircraft occupant comprising the steps of:
 - a) providing a user (7) with a breathing mask (4) for aircraft occupant,
 - b) providing a respiratory gas (62) including a mixture of breathable gas and dilution gas to the user (7),
 - 30 c) sensing partial pressure or percentage of oxygen or carbon dioxide in exhalation gas flow (64) generated by the user (7),

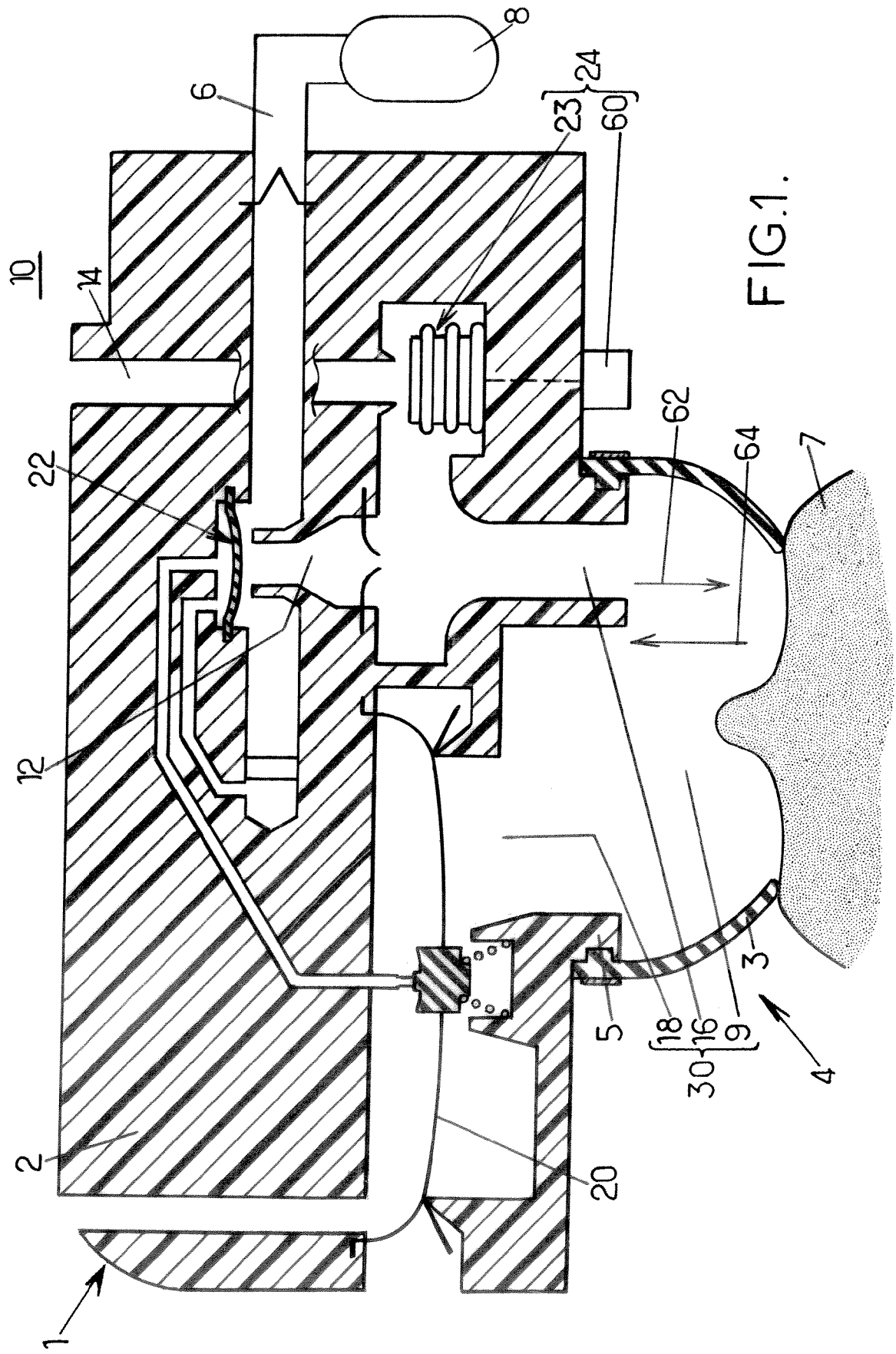
d) adjusting (60) the rate of oxygen or breathable gas in the respiratory flow (62) in accordance with the partial pressure or percentage of oxygen or carbon dioxide.

25. A breathing mask (4) for aircraft occupant including a demand
5 regulator (1), said regulator (1) comprising:

– a breathable gas supply line (12) to be connected to a source of breathable gas (8) and supplying a flow chamber (30) with breathable gas,

– a dilution gas supply line (14) to be connected to a source of dilution gas (10) and supplying the flow chamber (30) with dilution gas,

10 – a dilution adjusting device (24, 38, 42, 60) adjusting the rate of dilution gas in the respiratory gas (62) supplied to the flow chamber (30), the dilution adjusting device comprising a dilution valve (24) and a control device (60) controlling the dilution valve (24) in accordance with a dilution signal generated by the gas sensor (42) in function of the partial pressure or
15 percentage of oxygen or carbon dioxide in exhalation gas (64).



2/6

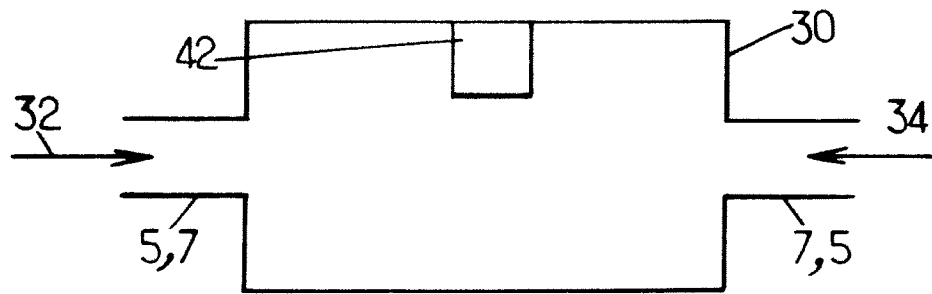


FIG.2.

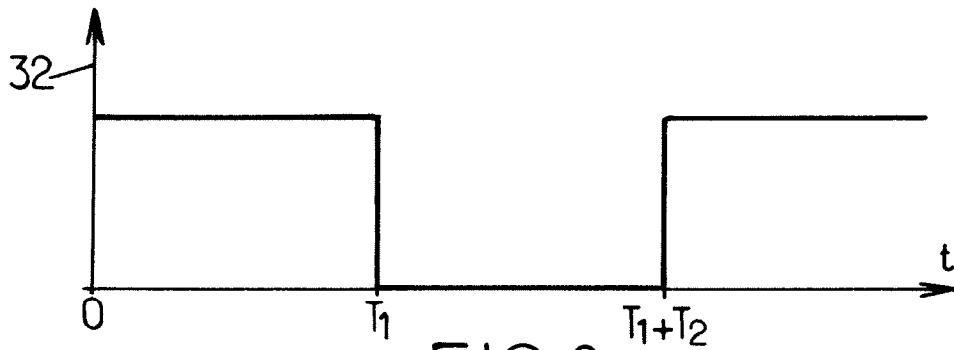


FIG.3.

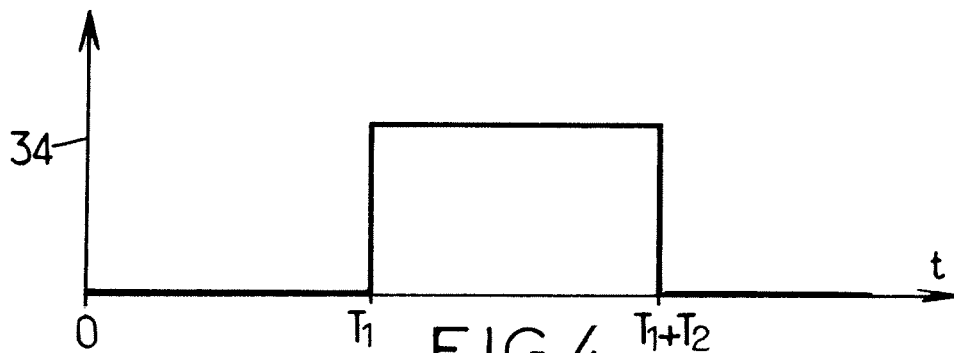


FIG.4.

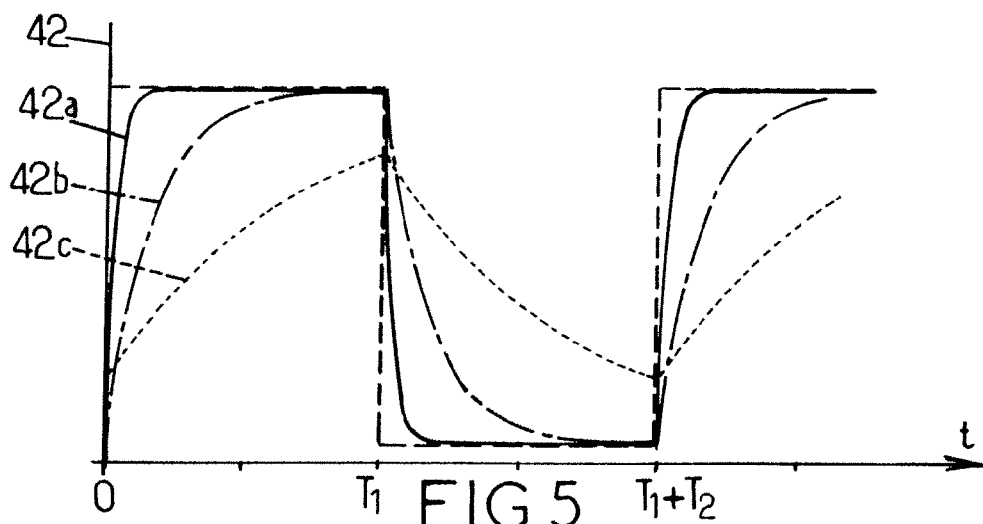


FIG.5.

3/6

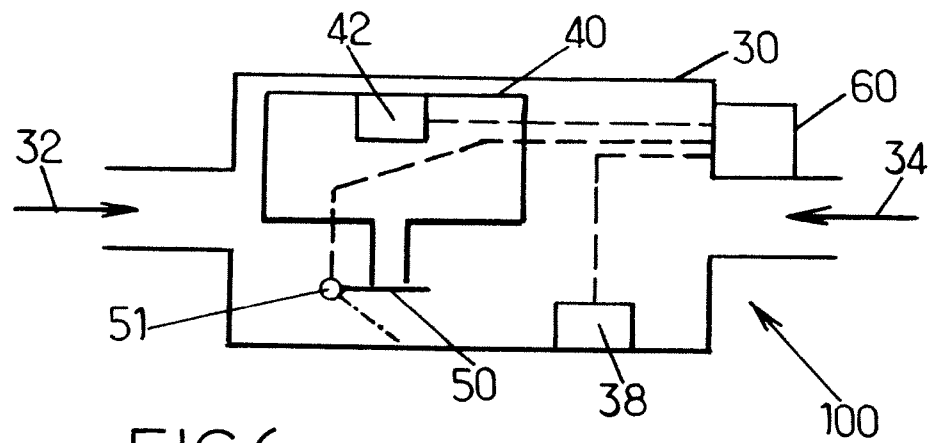


FIG. 6.

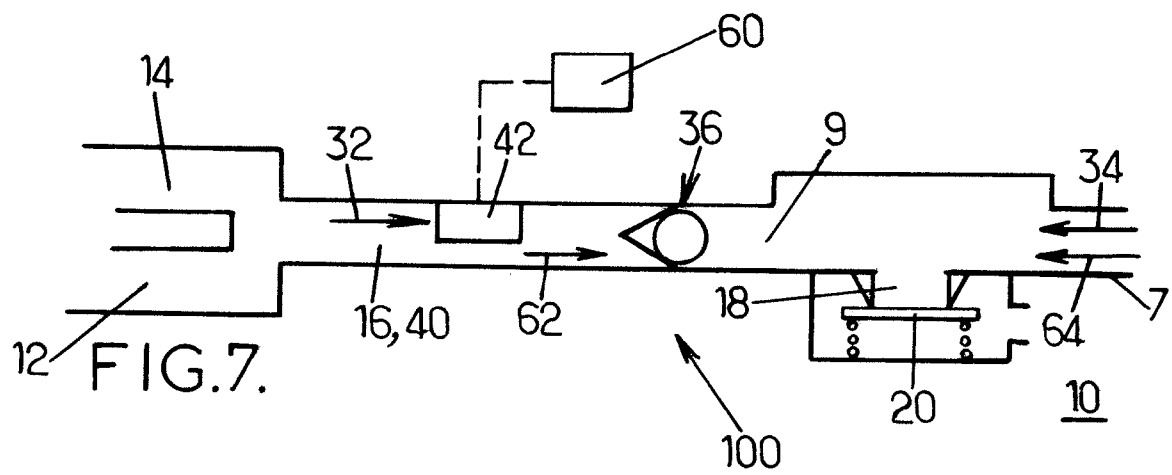


FIG. 7.

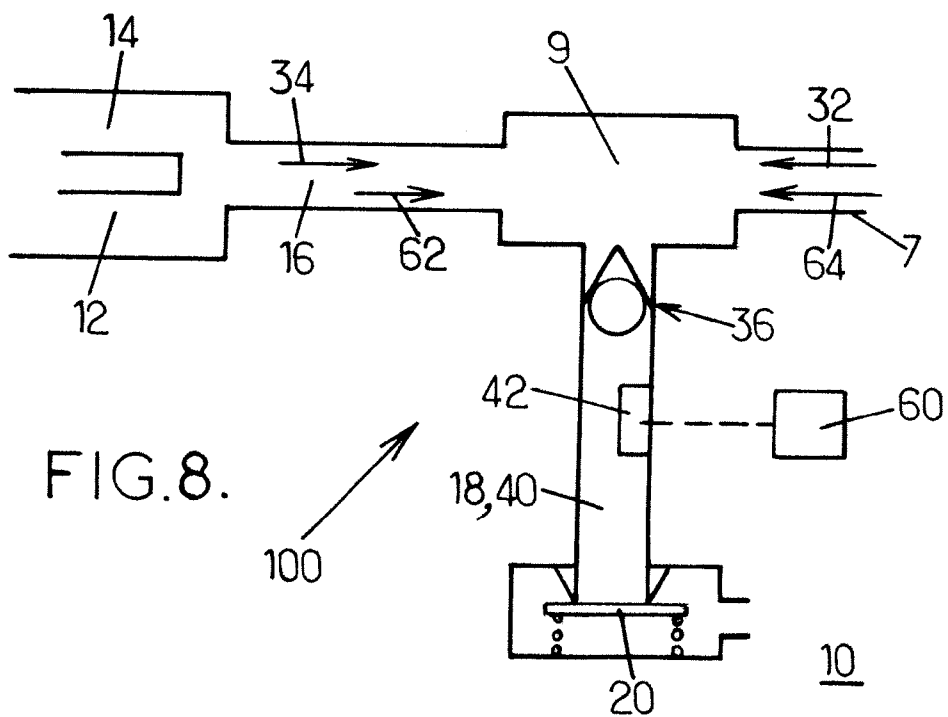


FIG. 8.

4/6

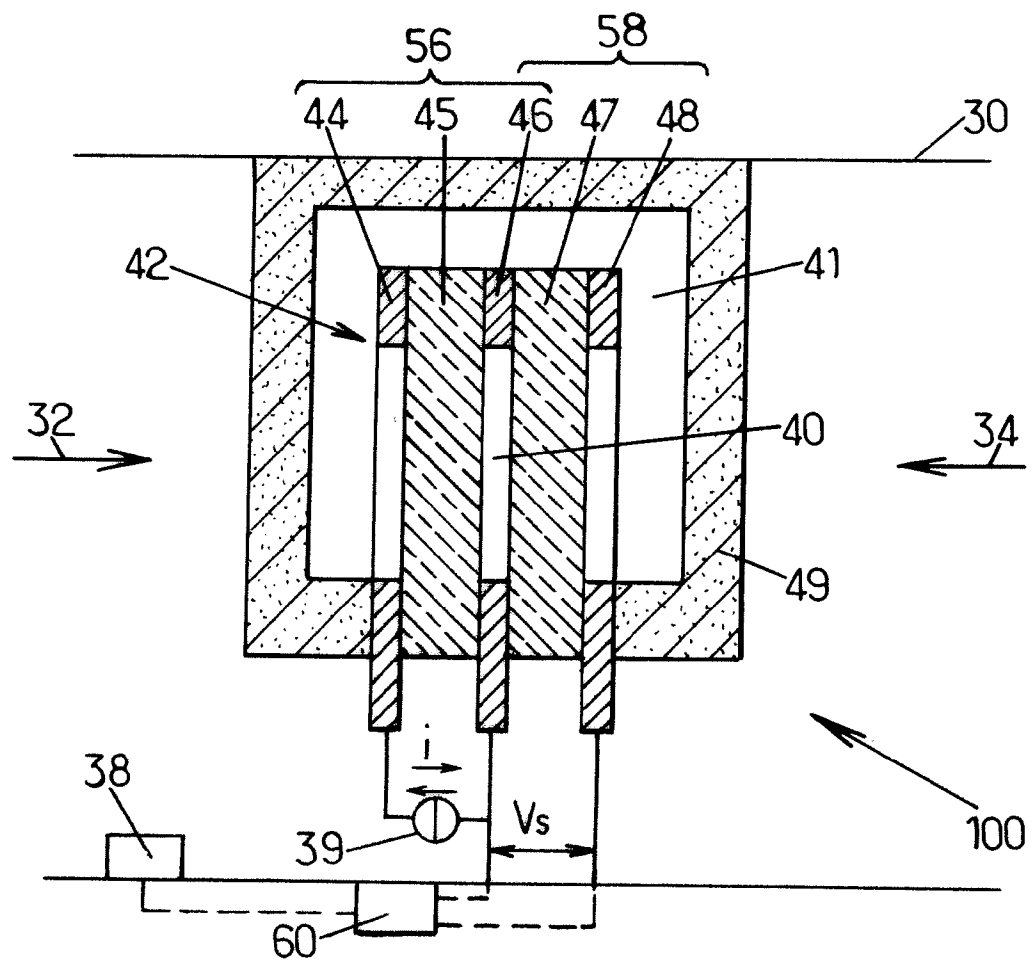


FIG.9.

5/6

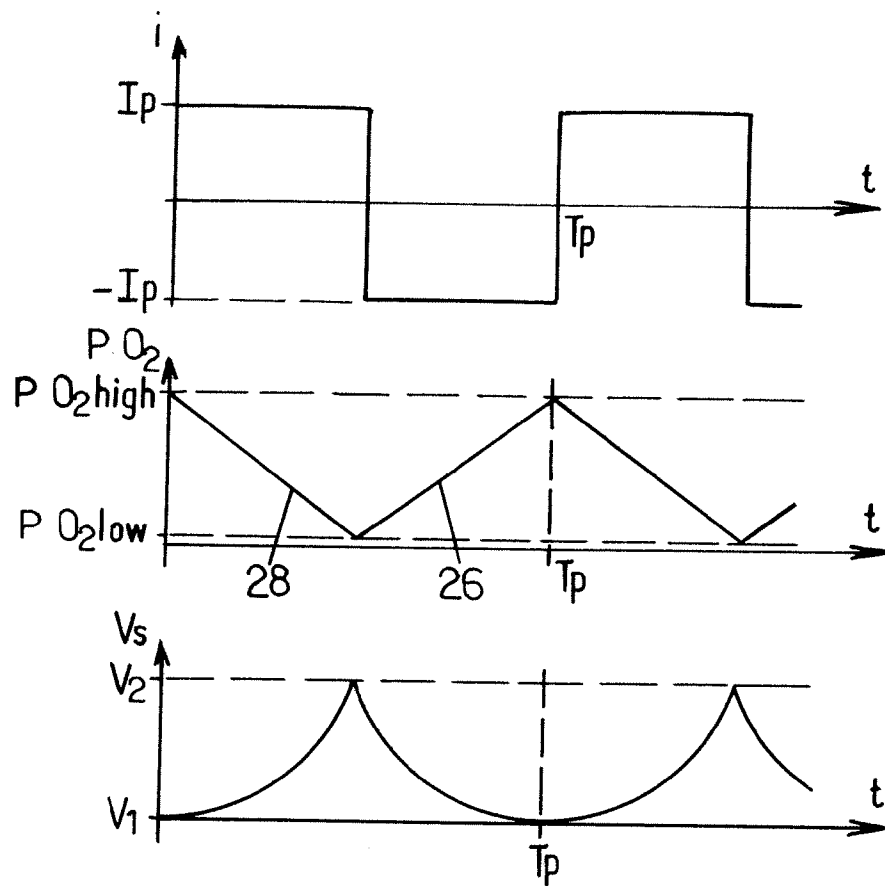


FIG.10.

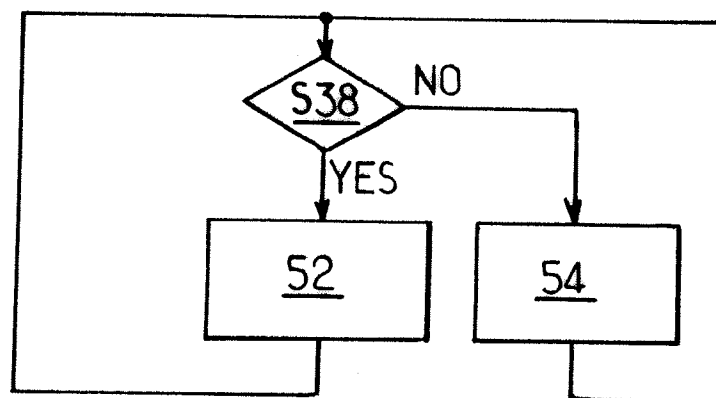


FIG.11.

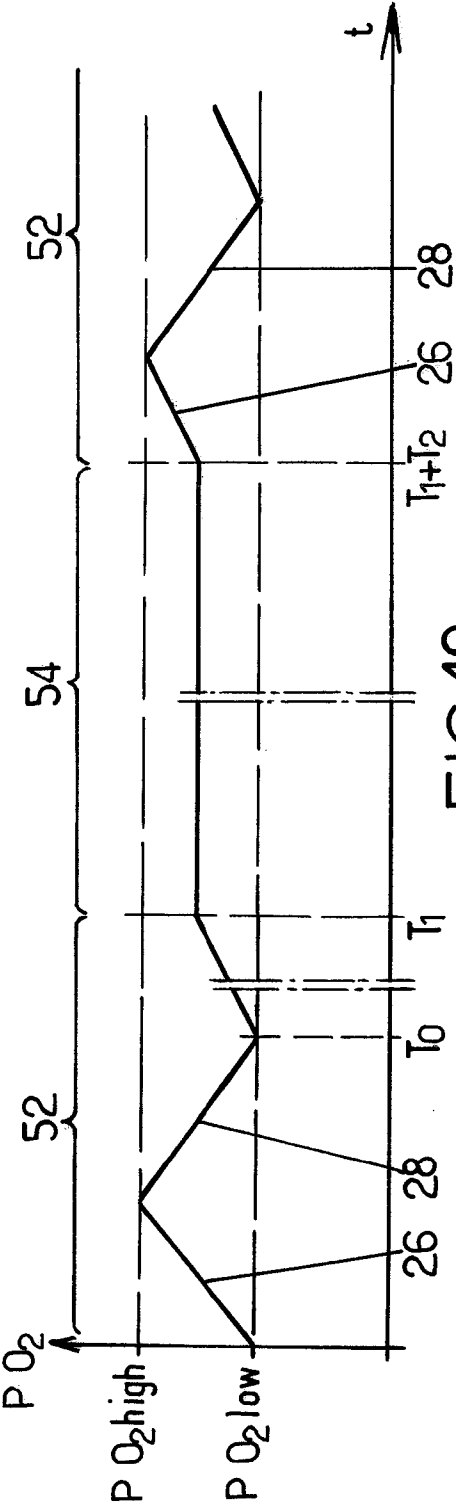


FIG. 12.

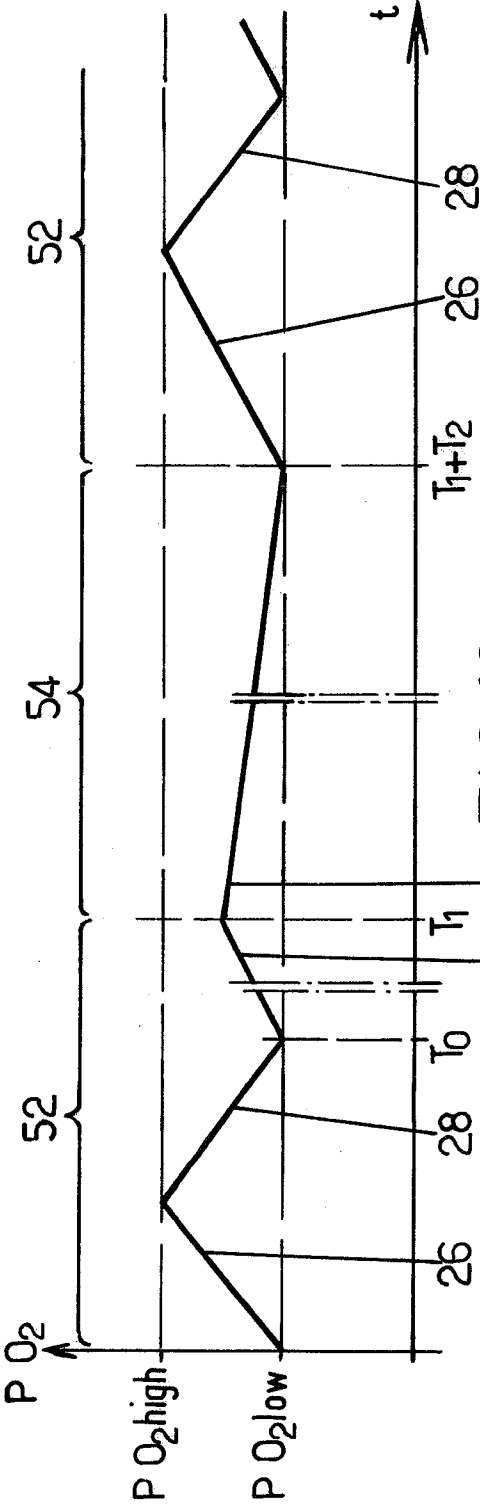


FIG. 13.

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2011/000781

A. CLASSIFICATION OF SUBJECT MATTER

INV. A62B7/14 A62B9/00 A62B9/02 B64D10/00
ADD.

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)

A62B B64D

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

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

EP0-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2009/013996 A1 (RITTNER ET AL) 15 January 2009 (2009-01-15) abstract; figure paragraph [0015] -----	1-4, 13-18, 20,24,25
X	US 3 395 701 A (BARTLETT JR ET AL) 6 August 1968 (1968-08-06) abstract; figures -----	1-3,5-8, 13,14, 16,21
X	US 7 040 319 B1 (KELLY ET AL) 9 May 2006 (2006-05-09) abstract; figures column 5, line 54 - column 6, line 7 -----	9-12,22, 23

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Further documents are listed in the continuation of Box C.

☒

See patent family annex.

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"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

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Date of the actual completion of the international search

19 July 2011

Date of mailing of the international search report

29/07/2011

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Authorized officer

Vervenne, Koen

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/IB2011/000781

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