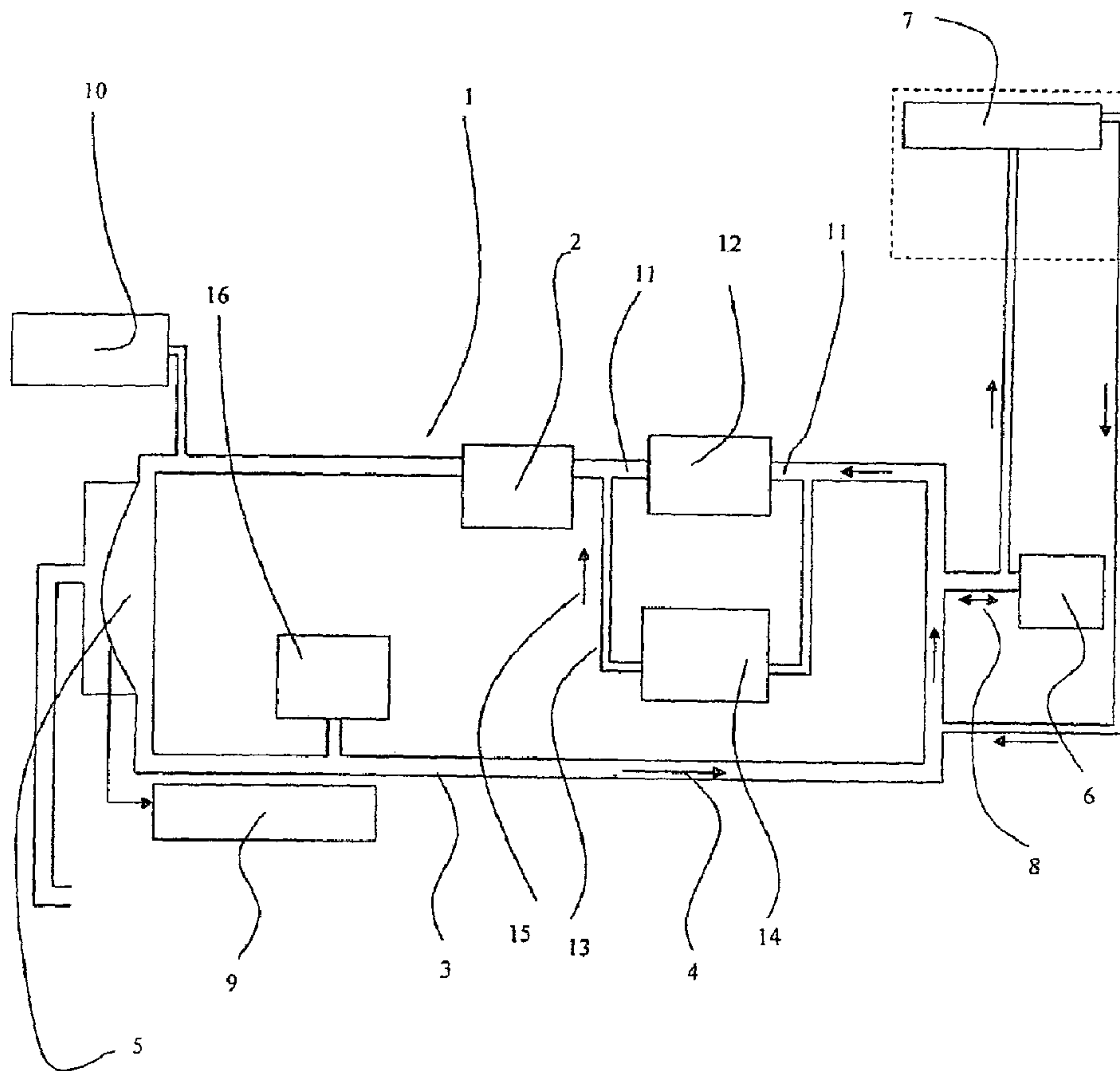




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 (72) **Inventeurs/Inventors:**
 BORM, PIETER, NL;
 WESTERKAMP, BART, NL
 (73) **Propriétaire/Owner:**
 LOWENSTEIN MEDICAL TECHNOLOGY S.A., LU
 (74) **Agent:** OSLER, HOSKIN & HARCOURT LLP

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(57) **Abrégé/Abstract:**

Apparatus for the respirating of patients with means for the circulating in one direction in a line system of gas, with supplies for the various components of the gas and with a line system part in which a carbon dioxide absorber device is provided, whereby the line

(57) Abrégé(suite)/Abstract(continued):

system further is provided with a by-pass line for leading of the respiratory gas outside of the line system part with the absorber device, characterized in that a control unit is provided by means of which the operating of the closing means takes place in dependence on one or more measurements of the concentration of carbon dioxide in the respiratory gas in the line system, and wherein the line system is provided with a circulation blower.

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NL-1826 DW Alkmaar (NL).

(72) Inventors; and

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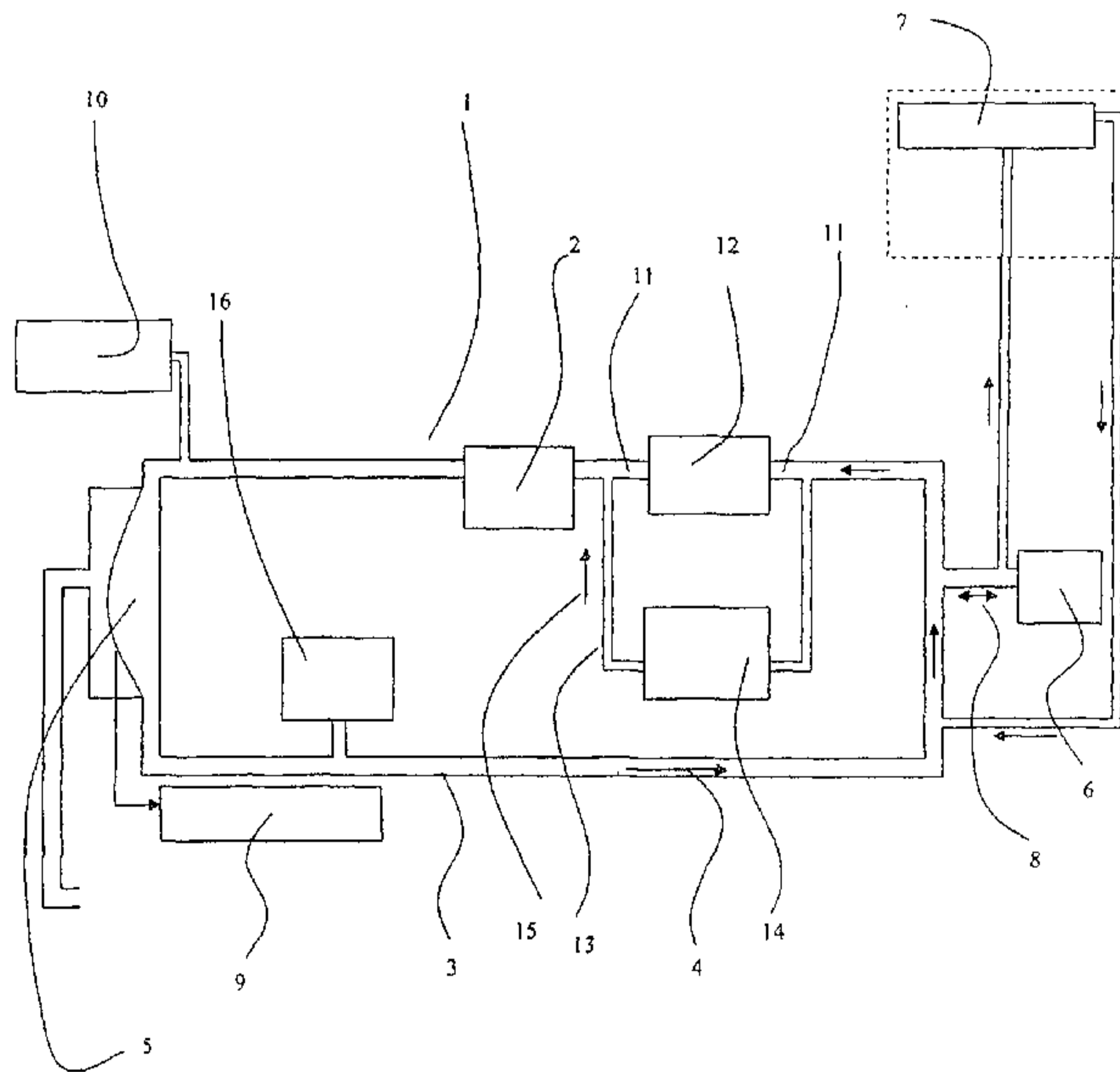


Figure 1

(57) Abstract: Apparatus for the respirating of patients
with means for the circulating in one direction in a line
system of gas, with supplies for the various components
of the gas and with a line system part in which a carbon
dioxide absorber device is provided, whereby the line
system further is provided with a by-pass line for lead-
ing of the respiratory gas outside of the line system part
with the absorber device, characterized in that a control
unit is provided by means of which the operating of the
closing means takes place in dependence on one or
more measurements of the concentration of carbon
dioxide in the respiratory gas in the line system, and
wherein the line system is provided with a circulation
blower.

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Apparatus for respirating of patients.

The present invention relates to an apparatus for the respirating of patients, for anesthesia through inhalation and for the administering of therapeutic gases through
5 inhalation, which apparatus is provided with means for the circulating in one direction in a line system of breathing gas, an anesthetic gas or a therapeutic gas, with means for varying the pressure in the line system in accordance with a certain respirating pattern, with means for measuring the flow of the gas and the
10 composition of the gas, whilst the line system is provided with connecting means for the patient and with further supplies for the various components of the respiratory gas and with a line system part in which an absorber device is provided for the withdrawing of the carbon dioxide exhaled by the patient in the line system.

Such an apparatus is known.

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From medical considerations it may be desirable to maintain or alter a certain amount of carbon dioxide in the respiratory gas, so that it can get more near the desired bodily values. This can be attained by changing the ventilation or rather the respiration. This however influences for instance the intake or release of oxygen or
20 another gas. This may be undesirable. It is further known to enrich the inhalation gas with carbon dioxide. Also are known apparatuses, in which the line system is provided with a by-pass line with closing means by means of which the respiratory gas completely or partly can be led outside of the line system part in which the absorber device is provided, and whereby, in this manner, the absorber device can
25 completely or partly be switched out, so that no or less removal of the carbon dioxide exhaled by the patient takes place. The patient then breathes in again the gas that is led through the by-pass line (rebreathing).

Like this the US patent US-A 6 131 571 describes an apparatus in which in the line
30 system a by-pass line is provided by means of which the respiratory gas can be led outside of the line system part containing the absorber device. This publication describes that in the case in which it is intended to quickly wash away vaporous anesthetics out of the line system, the by-pass line is opened to lead the respiratory

gas outside the absorber device. This makes it possible to ventilate the patient quickly without the concentration of CO₂ in the body decreasing too much.

5 This known apparatus does not comprise means by which the opening and closing of the by-pass line can be controlled in dependence on a measurement in the line system of the concentration of CO₂ in the respiratory gas.

10 The International application WO-A-9636385 describes an apparatus in which a device for analysing gas is provided, on the basis of which personnel can operate a valve in a by-pass line by means of which the respiratory gas completely or partly can be led outside of the line system part in which the absorber device is provided.

15 The International application WO-A-9940961 describes an apparatus in which in a line system a by-pass line is provided by means of which respiratory gas completely or partly can be led outside of the line system part in which the absorber device is provided, while the completely or partly opening and closing of the by-pass line is controlled by a control unit in dependence on a measurement of the concentration of CO₂ in the respiratory gas in the line system. With this known apparatus it is aimed for to maintain the concentration of CO₂ in the blood at a particular level, in order to prevent a long lapse of time between the end of the anesthesia and the beginning of the spontaneous breathing.

25 This known apparatus has the drawback, that the adapting of the concentration of CO₂ in the gas to the desired level comes about rather slowly relative to the changes in the body, that is to say, takes longer than 5 minutes, while a change in the body of the patient can take place within 2 minutes. Because of this it is not possible to realize a quick and accurate control of the amount of CO₂ in the respiratory gas at the end of a respiratory movement of the patient (endtidal CO₂ ; et CO₂), which is of great importance in case of for instance operations on the brain. In case of operations on the brain it is desired that the PCO₂ in the brain remains constant. The PCO₂ in the brain is directly related to the PCO₂ in the blood and this in turn is related to the end-tidal concentration of CO₂.

30 Also it is desirable during these operate interventions to maintain the supply of oxygen to the body optimum. Hyperventilation may be desirable. However one then

has to apply rebreathing to keep the end-tidal concentration of CO₂ at level. The problem is, that a change in the end-tidal concentration of CO₂ can occur quickly (within a few minutes). In the present rebreathing systems the time of response is very long, from many minutes to over 30 minutes. Because of this the known method of control is not suitable for optimum clinical use.

The invention aims to obviate this drawback of the known apparatus and to provide an apparatus, by means of which a more accurate control of the amount of carbon dioxide in the respiratory gas can take place.

The apparatus according to the invention to that end is characterized, in that a control unit is provided by means of which the operating of the closing means takes place in dependence on one or more measurements of the concentration of carbon dioxide in the respiratory gas in the line system, and wherein the line system is provided with a circulation blower.

According to a characteristic of the apparatus according to the invention the circulation blower has a capacity between 15 and 120 litre per minute.

According to a further characteristic of the apparatus according to the invention the circulation blower has a capacity between 30 to 60 litre per minute.

According to a further characteristic of the apparatus according to the invention the capacity of the circulation blower is adapted to the volume of the line system, in such a way, that the duration of one circulation of the gas is 10 seconds at the most, more in particular 5 seconds at the most, more in particular 3 seconds at the most.

According to a further characteristic of the apparatus according to the invention the duration of one circulation is 2,5 seconds at the most.

With the apparatus according to the invention it is possible to accurately maintain the concentration of carbon dioxide in the body of the patient at the desired level. More in particular it is possible to ascertain immediately a physiological change in the patient that is occurring all of a sudden, to determine the ratio between the flow

through the absorber device and the flow outside of the absorber device and to bring the concentration of carbon dioxide at the desired level by a quick mixing by means of the circulation blower.

5 According to yet a further characteristic of the apparatus according to the invention in at least two places in the line system means are provided for the measuring of the concentration of CO₂ in the gas.

10 According to another characteristic of the apparatus according to the invention one of the means for the measuring of the concentration of CO₂ in the gas is provided near the connection to the patient, more in particular at the mouth of the patient.

15 According to a further characteristic of the apparatus according to the invention one of the means for the measuring of the concentration of CO₂ in the gas is provided in a part of the line system outside the connection to the patient.

20 According to a further characteristic of the apparatus according to the invention one of the means for the measuring of the concentration of CO₂ in the gas is provided in a part of the line system which, as seen downstream, is positioned behind the means for the varying of the pressure in the line system.

Further characteristics and features of the invention will be described with reference to the drawing of an example of an embodiment.

25 Figure 1 schematically shows an example of an embodiment of the apparatus according to the invention.

Figure 2 shows a part of another example of an embodiment of the apparatus according to the invention.

30

As is shown in figure 1, the apparatus 1 is provided with means, such as a circulation blower 2, for the circulating in one direction 4 in a line system 3 of respiratory gas, and of means 5, for instance a membrane or bellows, for varying the pressure in the

line system 3 in accordance with a certain respirating pattern to make possible the respiration of the patient 6.

Further means are provided, such as an apparatus 7, for determining the composition of the gas inhaled and the gas exhaled 8 by the patient. In the drawing is shown the principle of sampling removal. If so desired the gas that has been removed can be fed back into the system. It is also possible to make use of a measuring system directly in the gas inhaled and the gas exhaled 8. In the closed system by means of the sensor 9 the volume or the flow of the respiration by the patient can be measured, during spontaneous respiration as well as during breathing upon the patient or in a given case supportive breathing upon the patient. The apparatus 10 provides the supply of the gases and the vaporous anaesthetics into the system.

In the example of the embodiment shown, in the line system 3, as seen in the direction of circulation 4 of the respiratory gas, in front of the circulation blower 2 a line system part 11 is provided, in which is comprised the absorber device 12 for the withdrawing of the carbon dioxide exhaled by the patient in the line system. To the line system 3 further a by-pass line 13, extending parallel to the line system part 11, is connected, by means of which the respiratory gas can be led completely or partly outside the line system part 11 containing the absorber device 12. In the by-pass line 13 a regulating device 14 is provided, for instance a regulating valve, by means of which the ratio between the volume of the flow 15 of respiratory gas through the by-pass line 13 and that through the absorber device 12 can be adjusted. By means of this the extent to which the patient breathes in gas that has been purified from carbon dioxide can be adjusted, and as a consequence thereof the amount of carbon dioxide in the body can be adjusted.

In the example of the embodiment shown at at least two places in the line system measuring devices are provided for the measuring of the concentration of CO₂ in the gas, whereby one measuring device 7 is provided near the mouth of the patient 6 and a second measuring device 16 is provided in the part of the line system which, as seen in the direction 4 of the gas flow, is positioned behind the membrane or bellows 5.

By means of a control unit the operating of the regulating valve 14 takes place in dependence on the measurements of the concentration of carbon dioxide in the respiratory gas at the mouth of the patient by the measuring device 7 and further on in the line system by the measuring device 16. On the basis of these measurements
5 the regulating valve 14 is operated and by means of that the ratio between the flow 15 of respiratory gas through the bypass line 13 and that through the absorber device 12 is adjusted. By means of this the extent to which the patient breathes in gas that has not been purified from carbon dioxide is adjusted, and as a consequence thereof the amount of carbon dioxide in the respiratory gas at the end of a respiratory
10 movement of the patient, de etCO₂.

The determination of the end tidal concentration of CO₂ through the respiration is dependant on the blood circulation. In adults the duration of one circulation of the blood is about 24 seconds; in infants about 9 seconds. The control system has to be
15 quicker than the human, whereby a given is that for a significant change of the concentration of CO₂ in the gas the length of time taken up by one circulation of the gas in the line system shall not be more than a third of the length of time involved with one circulation of the blood in the patient. Thus, a system for only adults has to remain below 24 seconds; for infants below 3 seconds.

20 A guiding principle is that one circulation of the gas in the line system does not take more than three seconds, preferably 2,5 seconds.

In this example of an embodiment the volume of the line system is 2,5 litre while in the line system a circulation blower is provided having in this example of an
25 embodiment a capacity of 60 litre per minute. This results in a circulation time of:
 $2,5 \text{ litre} / 60 \text{ litre/min} = 0.042 \text{ minutes} = 2,5 \text{ seconds}$.

Taking 2,5 seconds as a guiding principle, in the case of for instance a volume of the line system of 1,25 litre a circulation blower having a capacity of 30 litre per minute
30 has to be applied, in the case of a volume of the line system of 5 litre a circulation blower having a capacity of 120 litre per minute has to be applied, and in the case of a volume of the line system of 0,625 litre a circulation blower having a capacity of 15 litre per minute has to be applied.

With the application of a circulation blower, the capacity of which is adapted to the volume of the circuit, it is possible to bring about and maintain a sufficient fastness of circulation. With this it is attained that the mixing is quicker than that of the processes in the patient, so that a quick and accurate regulation is possible of the etCO₂. This is essential to an adequate control of the et CO₂, by which for instance during hyperventilation de et CO₂ remains at the desired level, notwithstanding changing processes in the patient. By continuously measuring of the concentration of CO₂ by means of the measuring devices 7 and 16 respectively at the mouth and further on in the circuit it is possible to ascertain the correct functioning of this quick regulation.

With the apparatus according to the invention, more in particular the application of a circulation blower for providing a sufficiently fast circulation and the control of the ratio between the volume of the gas flow through the bypass line and that through the absorber device on the basis of measurements at at least two places in the line system, it is possible to adequately control the et CO₂ irrespective of the extent of hyperventilation. Thereby the regulating valve with regard to the extent of rebreathing in combination with the measurement of the end-tidal CO₂ and the intrinsic fastness of the system as a consequence of the application of a circulation blower, an adjustment which is faster than the changes of the processes in the body is attained.

In an example of an embodiment not shown in the drawing the regulating device as an alternative can also be provided in the line system part 11 in series with the absorber device 12.

In figure 2 an example of an embodiment is shown, in which next to the regulating device 14 in the by-pass line 13 in the line system part 11 a further regulating device 17 is provided.

With the invention an apparatus is provided in which in parallel with the absorber device a by-pass line or rather by-pass is provided with either a regulating device in the flow through the absorber apparatus or a regulating device in the flow through the by-pass, and by means of which the breathing in again of carbon dioxide by the

patient (rebreathing of carbon dioxide) can be regulated, by means of which the amount of carbon dioxide in the respiratory gas at the end of a respiratory movement of the patient (et CO₂; endtidal CO₂) can be regulated at the desired physical level, while the ventilation is allowed to vary.

5

With the apparatus according to the invention by means of the increased ventilation the gases or in a given case vapours supplied to the patient can be increased to attain a faster wash in of the patient.

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Further by means of the increased ventilation the gases or in a given case vapours given off by the patient into the system can be increased in order to obtain attain a quicker wash out of the patient.

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The embodiments of the present invention for which an exclusive property or privilege is claimed are defined as follows:

1. An apparatus for respirating of patients, for anesthesia through inhalation and for administering of therapeutic gases through inhalation, which apparatus is provided with means for circulating in one direction in a line system of breathing gas, an anesthetic gas or a therapeutic gas, means for varying a pressure in the line system in accordance with a certain respirating pattern, means for measuring flow of the gas and a composition of the gas, whilst the line system is provided with connecting means for the patient and with further supplies for various components of the gas and with a line system part in which an absorber device is provided for withdrawing of carbon dioxide exhaled by the patient in the line system, whereby the line system further is provided with a by-pass line with closing means for completely or partly leading of the respiratory gas outside of the line system part with the absorber device, characterized in that a control unit is provided by means of which operating of the closing means takes place in dependence on one or more measurements of a concentration of carbon dioxide in the respiratory gas in the line system, and wherein the line system is provided with a circulation blower.
2. The apparatus according to claim 1, wherein the circulation blower has a capacity of 15 to 120 litres per minute.
3. The apparatus according to claim 1, wherein the circulation blower has a capacity of 30 to 60 litres per minute.
4. The apparatus according to claim 1, 2 or 3, wherein the capacity of the circulation blower is adapted to a volume of the line system in such a way, that a duration of one circulation of the gas is 10 seconds at the most.
5. The apparatus according to claim 1, 2 or 3, wherein the capacity of the circulation blower is adapted to a volume of the line system in such a way, that a duration of one circulation of the gas is 5 seconds at the most.
6. The apparatus according to claim 1, 2 or 3, wherein the capacity of the circulation blower is adapted to a volume of the line system in such a way, that a duration of one circulation of the gas is 3 seconds at the most.

7. The apparatus according to claim 1, 2 or 3, wherein the capacity of the circulation blower is adapted to a volume of the line system in such a way, that a duration of one circulation of the gas is 2.5 seconds at the most.
8. The apparatus according to any one of claims 1 to 7, wherein the circulation blower has a capacity of 60 litres per minute, while a volume of the line system is 2.5 litres.
9. The apparatus according to any one of claims 1 to 7, wherein the circulation blower has a capacity of 30 litres per minute, while a volume of the line system is 1.25 litres.
10. The apparatus according to any one of claims 1 to 7, wherein the circulation blower has a capacity of 120 litres per minute, while a volume of the line system is 5 litres.
11. The apparatus according to any one of claims 1 to 7, wherein the circulation blower has a capacity of 15 litres per minute, while a volume of the line system is 0.625 litre.
12. The apparatus according to any one of claims 1 to 11, wherein in at least two places in the line system means are provided for the measuring of the concentration of CO₂ in the gas.
13. The apparatus according to claim 12, wherein one of the means for the measuring of the concentration of CO₂ in the gas is provided near the connection to the patient.
14. The apparatus according to claim 12 or 13, wherein one of the means for the measuring of the concentration of CO₂ in the gas is provided in a part of the line system outside the connection to the patient.
15. The apparatus according to claim 12, 13 or 14, wherein one of the means for the measuring of the concentration of CO₂ in the gas is provided in a part of the line system which, as seen downstream, is positioned behind the means for the varying of the pressure in the line system.
16. The apparatus according to any one of claims 1 to 15, wherein regulation means are provided by means of which the ratio between the volume of the gas flow through the by-pass line and that through the absorber device can be regulated.

17. The apparatus according to claim 16, wherein the regulating means are formed by a regulating device provided in the by-pass line.
18. The apparatus according to claim 16, wherein the regulating means are formed by a regulating device provided in the line system part or in the absorber device.
19. The apparatus according to claim 17 or 18, wherein the regulating device is formed by a regulating valve.
20. The apparatus according to any one of claims 1 to 19, wherein the by-pass line runs parallel to the line system part with the carbon dioxide absorber device.

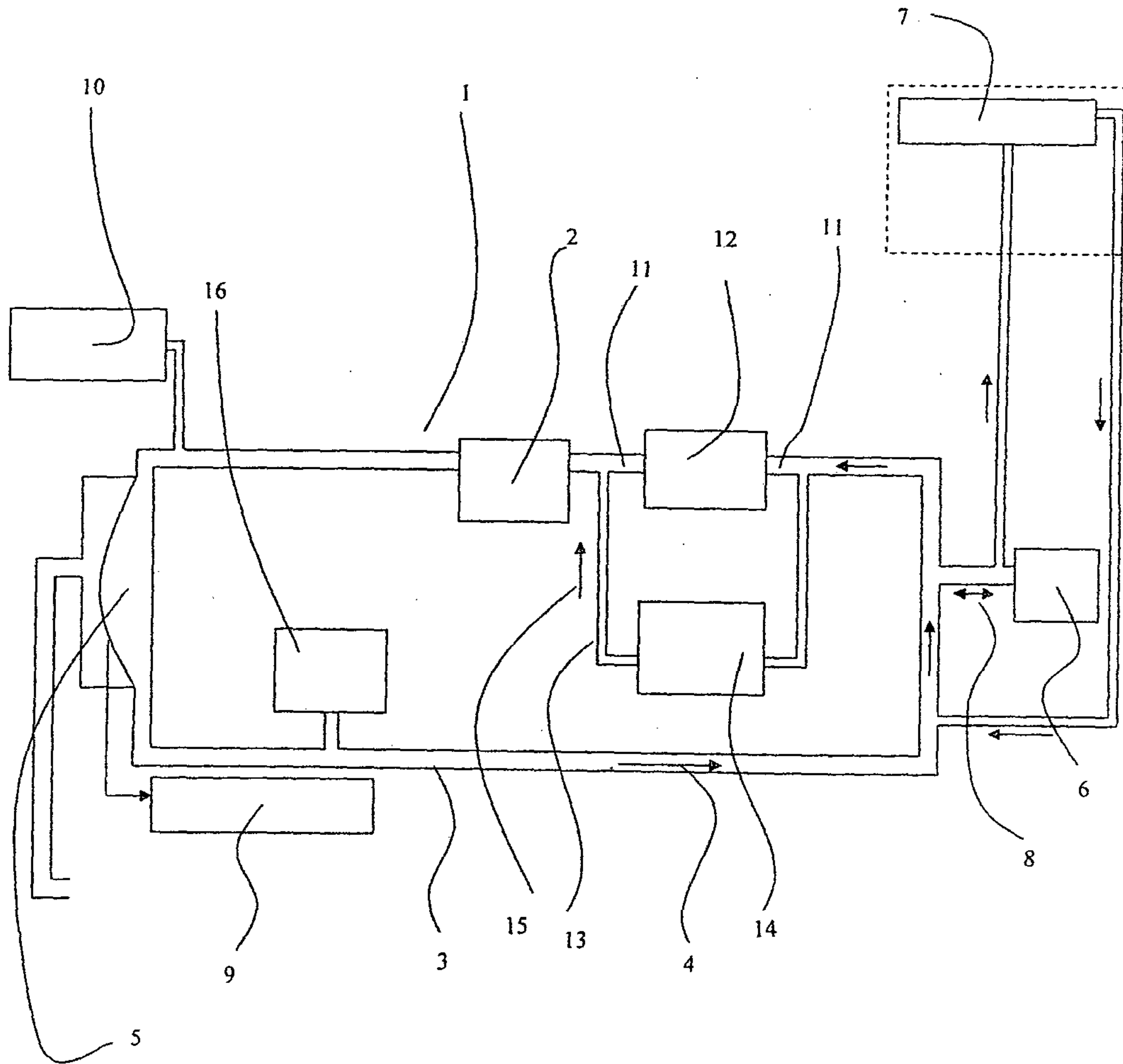


Figure 1

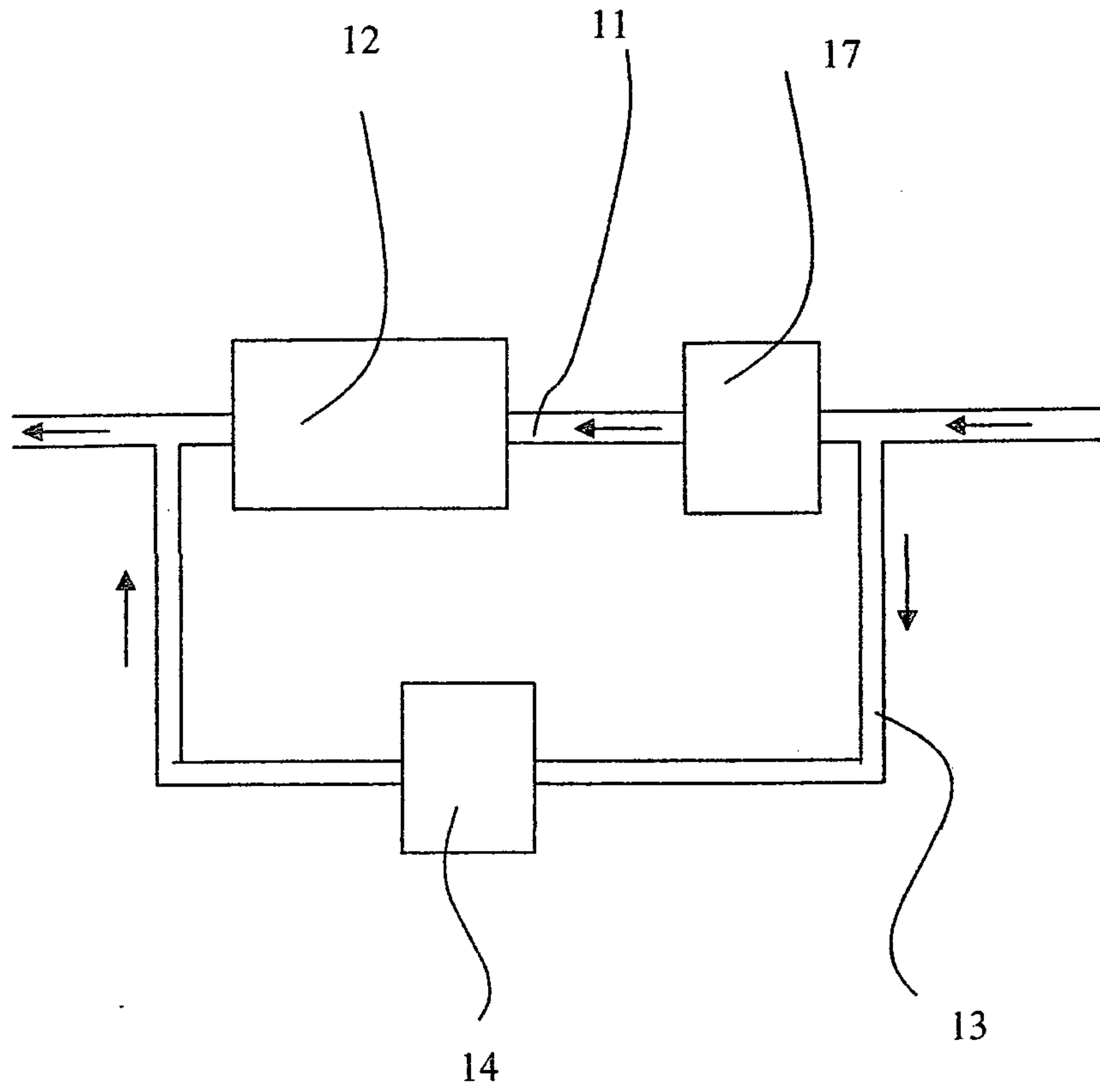


Figure 2

