Anaesthetic and/or ventilator system comprising a recirculation circuit (e.g. 105 in Fig. 5) connectable to the patient for recirculation of the patient's exhausted air, and provided with an inlet (106) for fresh gas and absorption unit (112 or 111) for removal of mainly CO₂. The system is characterized by a second absorption unit (112 or 111) connectable in series with said absorption unit for removal of CO₂, whereby said two units are connected in the system so that the unit (111) connected upstream can be totally consumed, whilst the unit (112) connected downstream is only partially consumed before exchange of the upstream unit (111) takes place. The system is preferably provided with a valve system such that one or both absorption units (111, 112) are by-passed by a by-pass conduit (6, 117, 117A, 117B, 119, 121, 122 or P) as soon as one unit is removed. The invention also includes a method for regenerating the circulating gas in a system of the above mentioned type.
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+ Any designation of “SU” has effect in the Russian Federation. It is not yet known whether any such designation has effect in other States of the former Soviet Union.
TITLE

ANAESTHETIC- AND/OR VENTILATOR SYSTEM AND METHOD TO PURIFY THE GAS IN SUCH A SYSTEM.

TECHNICAL FIELD

The invention relates principally to an arrangement in gas purifiers of the type which is used in anaesthetic machines for so called circle systems, i.e. systems in which an anaesthetic gas mixture, a mixture of air or oxygen and anaesthetic gas and possibly laughing gas (nitrous oxide) is allowed to circulate in a closed cycle from which the patient can inhale and into which the patient can also exhale. In order to maintain the intended gas proportions and to replace gas lost through leakage or the like, so called fresh gas is gradually supplied to the closed cycle. The gas mixture in the closed cycle must, however, continuously pass a gas purifier in order that particularly the CO₂ content shall not become too high. The gas purifier can be arranged either before or after the inlet for the fresh gas.

BACKGROUND ART

From the middle of the 1800’s chloroform anaesthetic with purification by means of calcium hydroxide was used in a closed system. In 1867 a change was made to calcium hydroxide instead so that in 1907 a lime compound popularly known as "Soda Lime" began to be used. This compound is in use even today.

Already in 1917 experiments had been made to determine the optimal grain size and this remains unchanged today.
During the 50's "Halotan" was introduced as an anaesthetic agent and found wide spread use together with laughing gas. In more recent times, isofluranate has been developed which is considerably kinder to the human metabolism though at the same time it is much more expensive than the "Halotan".

During the 60's and 70's the financial situation of the health-care system was good and "Halotan" compared with isofluran relatively cheap. For these reasons, systems with ventilators of non-rebreathing type were used during gas anaesthetic administration.

The development today is controlled in a better financial light and taking advantage of new expensive inhalation anaesthetic agents, and aims are made towards rebreathing systems of circulation type with an integral absorber function in the system. With such systems, it is normal to be able to reduce the fresh gas requirement by between 50-80%.

In a known example of a absorber unit in a so-called circle system, the absorber unit is located such that the gas mixture in the circle system passes therethrough. During normal operation, the gas flow is guided by means of a valve system through a removably arranged container for an absorption agent situated next to a valve housing. The absorption agent is lime in granular form which absorbs undesirable constituents in the gas and is so treated that it thereby changes colour, usually from white to violet. The consumed lime can be emptied from the container after it is been removed from the valve housing. During exchange of the container - usually one or more newly filled containers are held in reserve - the circle system can be short-circuited by means of the valve arrangement so that the gas flow passes directly through the valve housing.

The known arrangement implies in general a low exploitation of the lime since the container is exchanged for a new one even when the colour change has only reached
50-75%, i.e. when 50-25% of usable lime remains. This occurs since it is desirable to avoid exchanging the container during anaesthesia administration and since it is undesirable to risk that the patient should start to show symptoms of increased carbon dioxide levels.

OBJECT OF THE INVENTION

The main object of the present invention is to provide an arrangement which, compared with the known art, offers considerably improved utilisation of the absorption agent, i.e. lime, and simplified handling and which furthermore preferably allows humidifying and prewarming of the supplied fresh gas. The humidification can however, also occur with help of humidification devices known per se which take moisture from the exhaled gas and return it to the inhaled gas. In such cases, such a device is located between the circle circuit and the patient.

A further object of the invention is to allow two containers for the absorption agent which are connected in the circle circuit to be able to be by-passed during container exchange, either simultaneously or alternately. In this way the working environment is improved since anaesthetic gas is prevented from being released thereinto. At the same time, the function of the apparatus is improved since the surrounding room air is prevented from entering therein. This is particularly important for low flows in the circle circuit.

SUMMARY OF THE INVENTION

The arrangement according to the invention is preferably based upon the idea of utilising cheap containers made from environmentally friendly, transparent single-use material connected in series, suitably to each other, so that the gas passes from the one to the other during removal of undesired substances, whereby the containers and their support are arranged to permit the
rearrangement of partially consumed containers and the exchange of completely consumed containers with the object of utilising the full capacity of such containers.

According to the invention the containers and/or the support can also be arranged in such a way that containers placed on the support are permanently marked so that they cannot be used again.

The arrangement according to the invention can also be arranged such that incorrect handling and measures are prevented by means of each operation requiring a double handgrip or similar.

More precisely, the invention comprises an anaesthetic and/or ventilator system comprising a recirculation circuit connectable to the patient for recirculation of the patient’s exhaled air and provided with an inlet for fresh gas and an absorption unit for removal of mainly CO₂, characterized by a second absorption unit connectable in series with said absorption unit for removal of mainly CO₂, whereby said two units are connected in the system so that the unit connected upstream can be totally consumed whilst the unit connected downstream is only partially consumed before exchange of the upstream unit takes place.

Preferably means are arranged for transferring the partially consumed units to an upstream location at the same time that the consumed unit is replaced with a new unit at a downstream location.

Particular advantages are attained, as will become apparent from the following description, if a valve system is connected to the system such that either or both absorption units are by-passed via a by-pass conduit as soon as one unit is removed.

Either one by-pass conduit can be arranged from one point in the recirculation circuit upstream of the two units to a point downstream thereof, or use can also be made of two by-pass conduits arranged one for each unit
from a point in the recirculation circuit upstream of the respective units to a point downstream thereof.

The invention also includes a method for regenerating the circulating gas in a recirculation circuit in an anaesthetic and/or ventilator system during removal of mainly CO₂ with help of an absorption unit, characterized in that the gas is also conveyed through a second absorption unit arranged downstream, whereby the two units are so adapted to each other that the downstream unit may only partially be consumed whilst the upstream unit is essentially entirely consumed, whereafter the consumed unit is removed at the same time that a new unit is connected downstream of the partially consumed unit, which partially consumed unit is thereafter totally consumed.

DESCRIPTION OF EMBODIMENTS

The invention will be described in the following in more detail with reference to the attached drawings in which

Fig. 1 shows in perspective a complete device according to the invention with the parts shown in the form of an exploded view,

Fig. 2 is a horizontal section through the main housing showing its principle of operation,

Fig. 3 is a diagrammatic sketch of a system according to the invention,

Fig. 4 shows a modified section of the block diagram according to Fig. 3,

Fig. 5 shows a further modification of the same section,

Figs. 6A-6C show a modified embodiment of the system according to the invention,

Figs. 6D-6E show a further modified embodiment,

Figs. 7A-7C show a further modified embodiment and Figs. 8-10 show another three modified systems according to the invention.
The device shown in Fig. 1 includes a main housing 1, a valve housing 2 attachable thereto and two absorption agent containers 3. The main housing 1 is, as can best be seen from Fig. 2, provided with a pair of parallel longitudinal conduits 4 and 5 and a transverse cylindrical opening 6 which partially intersects both conduits and in which a rotatable valve body 7 is arranged. In addition there are further conduits (not shown) which will be described in the following.

From one end of each of the parallel conduits 4 and 5, though at opposite location, connection conduits 8, 9 resp. extend to the housings 1 upper side 10 where they merge into connection openings or similar 11, 12 resp. for the absorption agent containers 3. The conduits 4 and 5 communicate - one of them directly and the other via a not shown transverse conduit - with connection seats 13, 14 resp. to which the valve housing 2 is connected by means of its connection components 15 and 16. A branch conduit 17 is connected to the conduit 4 and is provided with a connector part 18 to which a tube 19 for supply of fresh gas is connected.

The rotatable valve body 7 is provided with two rigidly arranged operating dials 20. Each of these has a peripheral flange 21 which projects above the upper side 10 of the housing 1. The flange 21 is provided with a notch 23 which may be T-shaped. The function of the flange and the notch will be described in connection with the containers 3.

The valve body 7, by means of the dials 20, is rotatable between three different positions, one in which direct connection is made within the parallel conduits 4 and 5 and thereby with the container connectors 11 and 12, one position shown in Fig. 2 where the conduits are bypassed so that a direct through-passage past the container connectors becomes possible, and a third position where all
the conduits are open and in communication with each other to permit flushing.

The valve housing 2 which is suitably made from a totally transparent material, presents a longitudinal conduit 24 whose one end connects to a connector 25 for a breathing bag and in which two non-return valves 26, 27 are arranged for control of the direction of the air/gas mixture which is breathed in and out respectively by the patient.

The valve housing 2 is fixedly secured to the main housing 1 by means of a projection 28 provided with a cap which is inserted in a bore in the housing 1 and is fastened there by means of a displaceable fork-like rod 29 arranged radially with respect to the projection and bore.

The containers 3, which are preferably made from a transparent material and in this case are pairwise mounted for cooperation with each other, consist of a curved jacket 30, a flat side 31 and upper and lower end pieces 32, 33 respectively.

An eye 34 and a hook 35 are symmetrically arranged on the upper edge of the flat side 31 of the respective containers and are so positioned that, when two containers are placed adjacent each other, they will work as a hinge and lock the containers together. After being hooked together and swung towards each other, openings 36 arranged alongside the upper edges of the containers' flat sides will meet each other, thereby establishing communication between the interiors of both containers. At the lower edges or corners of the flat sides are arranged pegs 37 which project outwardly and which are intended to pass into the notch 23 of each dial's 21 flange and, after rotation of the valve body by means of the dials, these pegs are held by the flanges 21. From this it is apparent that containers can only be mounted and removed when the dials 20, and thereby the valve body 7, are in a predetermined position. This position corresponds to that shown in
Fig. 2, namely in the position when the connection between the containers 3 is closed and the direct passage through the main housing is open.

A further projection in the form of a peg or a pin 38 is positioned at the lower edge of the arched outer surface of each container. Of the two pegs 38 which, in the containers' 3 joined position projects outwardly, one is intended to be inserted in a fixed hoop 39 on one of the short ends of the main housing whilst the other peg 38 is intended to be held with and fixedly secured by a pivotable fitting 40 arranged on the opposite short end of the upper side of the main housing.

During attachment of two joined and abutting containers, the one peg 38 is first introduced into the fixed hoop 39 whereafter the pair of containers is pushed downwardly towards the upper surface of the main housing until the second pin 38 can engage the fitting 40 and be fixedly held by this fitting.

On the underside 33 of each container 3 is arranged an asymmetrically positioned opening 41 and when the containers are joined together and attached to the main housing as described above these openings 41 engage with the connectors or openings 11 and 12 in the main housing 1. A so called distributor plate is positioned within the opening 41 at a predetermined distance, whose purpose is to spread the inflowing gas so that it reaches the maximum lime volume. Communication is established with the patient via the valve housing 2, the conduit 4, the conduit 8, the opening 11, one of the containers' bottom opening 41, the connection openings 36, the second container's bottom opening 41, the second connection opening 12 in the main housing, the conduit 9 and the conduit 5 back to the valve housing 2 and the patient.

In the shown embodiment, the branch conduit 17, with the connection 18 for the tube 19 by which fresh gas is supplied, is arranged to discharge into the conduit 4, i.e.
the conduit through which the patient's exhaled air passes in a direction towards the absorption containers. This means that the fresh gas is warmed and humidified before it, together with remaining gas, is breathed in by the patient. This is particularly valuable with the most commonly arising proportion of fresh gas to returned gas, i.e. ca 25-50%, preferably 35-40%.

The absorption agent which is used is such that, as it is being saturated, it takes on for example a blue colour. It can thus be visually ascertained if a container is saturated or not. A serious disadvantage is, however, that the blue colouring disappears after a while so that a container which has been left lying around for more than 24 hours can look as though it contains unused white absorption material. With the aim of eliminating the risk that saturated and thus unusable containers may be used again, the containers according to the invention can be provided with a type of indicator, namely a break-off tongue 43 arranged on the edge of the base 33, which tongue is arranged to be broken off during the placing of the container in its second position on the main housing 1 by means of a stud or similar 44 projecting from the upper surface of the main housing.

In the shown embodiment, just one such stud 44 is provided, which implies that the tongue 43 is broken only when the container is placed in its second position. Since unused containers are always placed first in the position where the gas re-enters the main housing in order to form a buffer for the container which meets the gas coming from the patient, any confusion there is of less importance and so no marking of the container is made there. On the other hand, when the container is placed in its second position the tongue 43 is broken off by the stud 44.

Alternatively, each container can be provided with two tongues in different locations and a stud can be arranged at each of the positions in different locations so
that one of the tongues is broken off when the first position is adopted and the second is broken off when the second position is adopted. In this way the risk of a used container coming into circulation again is totally eliminated.

Compared with known arrangements, as well as the above mentioned advantages, the arrangement according to Fig. 1 and 2 provides the following advantages.

A considerable saving of absorption material or lime is achieved since the lime can be virtually 100% used. This should be compared with the known system in which 25-50% of the lime is discarded unused.

By means of the indicating or coding system with break-off tongues or similar, unused containers can be kept separate from used containers even when the colouring has disappeared.

The fresh gas is humidified and heated by means of it being introduced before the absorption arrangement.

The transparent containers and valve housing make it easy to monitor the colouring of the lime as well as the functioning of the valve components.

All mounting and removal operations require the use of two hands, in addition to which the possibility of controlling this is provided by using the valve body's operating dials as the locking element for the containers so that they can only be unlocked when the valve is in a predetermined position.

The conduit systems are formed with flow-loss reducing stretches which also permit a more certain cleansing.

The distributor plate arranged within the container opening permits an improved utilization of the whole powder volume.

Finally, the possibility to complement the arrangement with a coupling plate should be noted, by means of which the entire equipment can be utilized with known
arrangements irrespective of the rigid refillable containers, which implies that the above described more rational handling system can also be employed with known devices.

A system according to the invention is shown more schematically in Fig. 3. Here the patient P is connected via a Y-piece 100 to both an exhalation conduit 101 and an inhalation conduit 102. These conduits include return valves 103, 104 respectively and form part of a recirculation system which is denoted in its entirety by reference number 105. Fresh gas is supplied via a conduit 106 from a source 107 for such a gas and a part of the recirculating gas can be removed via a conduit 108 with a valve 109. The recirculation is achieved in a manner known per se by bellows 110. Two absorption units 111 and 112 in the inhalation conduit are connected together with help of valves 113-116. By means of the valves 113 and 116, a bypass conduit 117 can automatically be connected if one of the units 111 and 112 is removed. Suitably the valves 114 and 115 are simultaneously closed so that anaesthesia gas cannot leak out. When the shown system is used, the unit 111 will automatically be consumed first. This is then replaced with the unit 112 which has only partially been consumed, at the same time that the new unit is introduced instead of the unit 112 between the valves 115 and 116.

In Fig. 4 it is shown how the by-pass conduit 117 can be replaced by two by-pass conduits 117A, 117B. This construction can, in effect, be used in the same way as the one according to Fig. 3. However, here the possibility exists to always have one of the units 111 and 112 connected.

A system is shown in Fig. 5 in which there is no need to move the units 111 and 112 from their respective positions before they are totally consumed. This is achieved with the help of a valve system and a further by-pass conduit 117C, at the same time that the valves 114 and
115 are exchanged for a multi-switchable valve 118. By means of the shown valves 113, 116 and 118 the gas can either be directed straight through the absorptions units 111 and 112 in the same way as in Fig. 3 and 4, or also past these units via by-pass conduits 117A and 117B. A further possibility, however, is that the gas is directed via valve 113, conduit 117A, valve 118 directly to the unit 112 and thereafter through the valve 116, the conduit 117C and valve 113 to the unit 111 and therefrom further via the valve 118, the conduit 117B and the valve 116 to the patient.

Yet another alternative solution is shown in Figs. 6A-6C, in which both the absorption units 111 and 112 can be by-passed with help of a single multi-switchable valve 119. In Fig. 6A the two units 111 and 112 are shown connected in series with the unit 111 arranged upstream. In Fig. 6B the two units are shown by-passed by means of a by-pass conduit in valve 119. The two units 111 and 112 are shown in Fig. 6C connected in series again but now with the unit 112 arranged upstream. With this solution the need for the units 111 and 112 to exchange places no longer exists. It is necessary only to change the direction of flow.

A further alternative solution is shown in Figs. 6D-6E. With this solution the two units 111 and 112 are arranged on a rotating base or similar 120, so that they can be moved from the position shown in Fig. 6D to that shown in Fig. 6E. In a intermediate position during rotation, by-pass occur. Only in this position should the consumed unit be able to be replaced.

A further alternative is shown schematically in Figs. 7A-7C. The two units 111 and 112 are hereby connected in series in the recirculation circuit on two suitably spring-biased connector units 121 and 122. In order to extend the flow path through the two units 111 and 112, these are provided with partition walls 123. When the unit 111 is totally consumed, it is lifted so that the connector
unit automatically switches to the by-pass position as shown in Fig. 7B. When the unit 111 is then removed, the unit 112 can be moved as shown in Fig. 7C. In this position the two connector units 121 and 122 are automatically switched to the by-pass position in which they remain until the unit 112 is connected, and when a new unit is connected to the connector unit 122, respectively.

A further alternative is shown in Fig. 8. In this alternative, two units connected in series are denoted by Ca and Cb, and a replacement unit by Cc. The units are arranged to be able to be connected in a main conduit A-B, which is included in the recirculation circuit. At the same time, they are arranged to be able to be by-passed with help of the valves V1 and V2 and a by-pass conduit P. The flow direction can be said to be from A to B. When the unit Ca is consumed, it is removed as indicated with the arrow 1'. The unit Cb is moved down as indicated by the arrow 2' and the unit Cc is introduced at the vacant site as indicated with the arrow 3'. During the entire exchange, the valves V1 and V2 are so adjusted that the entire gas flow passes through the by-pass conduit P. The units Ca, Cb and Cc are provided with connections 201 and 202 which can be connected both to each other and to tube connectors 203 and 204.

A further alternative is shown in Fig. 9 which also comprises the main conduit A-B, the by-pass conduit P, the valves V1 and V2 and connectors 201', 202', 203' and 204' corresponding to the connectors 201-204 in Fig. 8. The various units have been denoted by C'a, C'b and C'c. Partition walls which are intended to extend the flow path for the respiratory gas are denoted by 205'. The operation of the arrangement according to Fig. 9 is principally the same as for that according to Fig. 8.

A further alternative is shown in Fig. 10. This alternative differs from that according to Fig. 9 principally by the addition of two further valves W1 and
W2. By means of these valves, the flow direction can be transposed so that the partially consumed unit C''b does not need to be moved when the completely consumed unit C''a is replaced with a new (not shown) unit. This alternative also includes partition walls 205'' and connectors 201''-204'' corresponding to the partition walls 205' in Fig. 9 and the connectors 201-204 in Fig. 8.

Naturally the invention is not restricted to solely the above described embodiments, but can be varied within the scope of the following claims. For example, the shown system can be complemented by further functions, for example pressure measurement, gas analysis, drying, humidifying and filtering.
CLAIMS

1. Anaesthetic and/or ventilator system, comprising a recirculation circuit (e.g. 105 in Fig. 3) connectable to the patient for recirculation of the patient's exhaled air, and provided with an inlet (106) for fresh gas and an absorption unit (111 or 112) for removal of mainly CO₂, characterized by a second absorption unit (112 or 111) connectable in series with said absorption unit for removal of mainly CO₂, whereby said two units are connected in the system so that the unit (111) connected upstream can be totally consumed whilst the unit (112) connected downstream is partially consumed before exchange of the upstream unit (111) takes place.

2. System according to claim 1, characterized by means arranged for transferring the partially consumed unit (112) to an upstream location at the same time that the consumed unit (111) is replaced with a new unit at a downstream location.

3. System according to claim 1 or 2, characterized by a valve arrangement such that either or both absorption units (111 and 112) are by-passed via a by-pass conduit (6, 117, 117A, 117B, 119, 121, 122 or P) as soon as one unit is removed.

4. System according to claim 3, characterized by a by-pass conduit (e.g. 117) from a point in the recirculation circuit upstream of both the units to a point downstream of these.

5. System according to claim 3, characterized by two by-pass conduits (e.g. 117A and 117B) arranged one for each unit (111, 112 resp.) from a point in the recirculation circuit upstream of the respective unit to a point downstream thereof.
6. System according to claim 5,
characterized in that respective absorption units and by-pass conduits are connected in the system such that the recirculating gas must always flow through at least one absorption unit (e.g. Fig. 4).

7. System according to any one of the preceding claims, characterized in that the two absorption units, as well as the means for connecting them, are essentially identical so that the two units are freely exchangeable with each other (e.g. Fig. 1).

8. System according to any one of the preceding claims, characterized by a valve system such that the sequential order of the two units in the direction of flow can be reversed without their needing to be moved (e.g. Fig. 5, Fig. 6A-6C, Fig. 6D-6E and Fig. 10.)

9. System according to claim 2, characterized in that the two units (111, 112) are connected in series on a rotatable base or similar (120) with help of which the direction of flow through them can be reversed (e.g. Fig. 6D-6E).

10. System according to claim 9, characterized by a valve system such that the two units (111, 112) are by-passed in a intermediate position during rotation of the base (120), whereby means are preferably arranged to permit exchange of units only in this intermediate position.

11. Method for regenerating the circulating gas in a recirculation circuit in an anaesthetic and/or ventilator system during removal of mainly CO₂ with help of an absorption unit, characterized in that the gas is also conveyed through a second absorption unit arranged downstream, whereby the two units are so adapted to each other that the downstream unit may only partially be consumed whilst the upstream unit is essentially entirely consumed, whereafter the consumed unit is removed at the same time that a new unit is connected downstream of
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the partially consumed unit, which partially consumed unit
is thereafter totally consumed.

12. Method according to claim 11,
characterized in that either or both
absorption units are by-passed by a by-pass conduit as soon
as the one unit is removed.
**INTERNATIONAL SEARCH REPORT**

International Application No: PCT/SE 91/00600

I. CLASSIFICATION OF SUBJECT MATTER (If several classification symbols apply, indicate all)

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC5: A 61 M 16/22

II. FIELDS SEARCHED

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Documentation searched other than Minimum Documentation to the extent that such Documents are included in Fields Searched

SE, DK, FI, NO classes as above

III. DOCUMENTS CONSIDERED TO BE RELEVANT

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  - "Y" document of particular relevance, the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - "A" document member of the same patent family

IV. CERTIFICATION

Date of Actual Completion of the International Search: 19th December 1991

Date of Mailing of this International Search Report: 1992-01-03

International Searching Authority: SWEDISH PATENT OFFICE

Signature of Authorized Officer: Lena Johansson
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ON INTERNATIONAL PATENT APPLICATION NO. PCT/SE 91/00600

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