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COMPLETE SPECIFICATION.

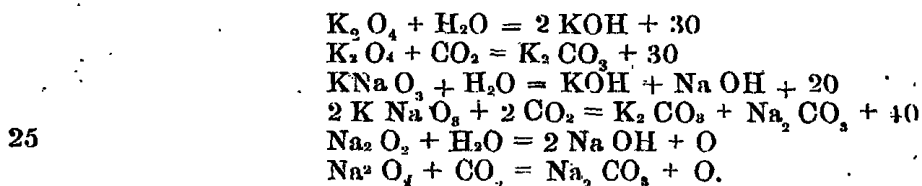
Improvements in the Process of and Apparatus for Regenerating  
Breathed Out Air for Respiration Purposes.

We, MAX BAMBERGER of 25 Seidlgasse, Professor at the Polytechnical University, FRIEDRICH BOCK of 16 Hengasse, Assistant Professor at the Polytechnical University and FRIEDRICH WANZ of 8 Bennoplatz, Engineer, all of Vienna, Austria, do hereby declare the nature of this invention and in what manner  
5 the same is to be performed, to be particularly described and ascertained in and by the following statement:—

Our invention relates to a process of and apparatus for regenerating breathed out air for respiration purposes.

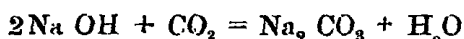
10 Our process consists in passing the breathed out air, which besides nitrogen and a reduced quantity of oxygen contains vapour of water and carbonic dioxide (the latter two forming the products of respiration), through a porous layer of alkali peroxide such as potassium tetroxide ( $K_2 O_4$ ) or sodium bioxide ( $Na_2 O_2$ ) or potassium sodium peroxide ( $KNa O_3$ ).

15 While the breathed out air passes through the alkali peroxide, thus coming into intimate contact therewith, a reaction takes place in which the alkali peroxide is reduced and gives off oxygen which mingles with the oxygen and nitrogen of the breathed out air and escapes together with them, and on the other hand the vapour of water and the carbonic dioxide combine with the  
20 alkali oxide resulting from such reduction to form alkali hydroxide and alkali carbonate respectively, as is shown by the following chemical equations:



The reaction is so energetic that the materials are heated to a temperature which will not permit the alkali carbonate that may be formed by the action  
30 of carbonic dioxide on alkali hydroxide to retain any water.

Therefore the action of carbonic dioxide contained in the breathed out air on the alkali hydroxide formed by the action of the water vapours of the  
breathed out air on the alkali peroxide, will result in setting free a corresponding amount of water as will be seen from the following equation:



35 which water will in turn decompose a corresponding quantity of alkali peroxide producing oxygen and alkali hydroxide as above explained.

It will be seen that the carbonic dioxide that was contained in the breathed out air, as also the vapour of water, is entirely absorbed by or combined with:

[Price 8d.]



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alkali oxide, while on the other hand the oxygen evolved during the reaction is added to the nitrogen and oxygen of the breathed out air. The amount of oxygen thus added depends on the nature of the alkali peroxide used; in the case of potassium tetroxide it is notably greater and in the case of potassium-sodium peroxide slightly greater, but in the case of sodium peroxide smaller, than the amount of oxygen that was contained in the carbonic dioxide and the vapour of water of the breathed out air. Therefore by mixing the alkali peroxides above named in suitable proportions we can so arrange that the amount of oxygen added to the breathed out air by the above reactions is exactly the same that was contained in the carbonic dioxide and vapour of water of the breathed out air. The latter will then after having passed through the alkali peroxide be entirely free from carbonic dioxide and vapour of water, and will contain nitrogen and oxygen in exactly the same proportions as the natural atmospheric air, or in other words the breathed out air will be regenerated or transformed into atmospheric air free from any contamination.

The air thus regenerated may be breathed in again directly.

In many cases it will be found advantageous to use sodium peroxide alone which, as above set forth does not add to the breathed out air the total amount of oxygen required, and to mix the air after having passed through the sodium peroxide and before being breathed in again, with oxygen obtained from a separate source.

In any case this process is self regulating in so far as the amount of oxygen added exactly corresponds to the amount of carbonic dioxide and vapour of water contained in the air breathed out irrespective of the irregularities that may occur.

In the accompanying drawing an apparatus for regenerating breathed out air in the manner above described is shown by way of example, the view shown being a vertical central section.

A is a receptacle preferably cylindrical in shape, D is a central tube in the same filled with water, B, C are annular chambers in the receptacle A, E<sup>1</sup> E<sup>2</sup> are filters tightly closing the chamber C at both ends and consisting of asbestos, glass wool, or other refractory filtering material, held in position between partitions of perforated sheet metal or wire gauze. F is a tube leading into a dome F<sup>1</sup> on the top end of the receptacle and adapted to be connected with a mask or other suitable respiratory apparatus. H is a bag of suitable air tight material connected by a short tube G to the central space L in the chamber B. J is a short tube connecting the water tube D with the interior of the chamber B, K is a pipe connecting the space L with the interior of the chamber B. 1, 2, 3, 4 are partitions of sheet lead or other similar suitable material, the partition 1 separating the dome from the filter E<sup>1</sup>, the partition 2 closing the top end of the tube D, the partition 3 separating the lower end of the tube D from the tube J and the partition 4 separating the central space L from the tube G. 5, 6, 7, 8 are perforating cones at the lower ends of rods 9, 10, 11 and 12 respectively and resting against the upper sides of the partitions 1, 2, 3 and 4 respectively. The said rods are suitably guided so that they are always in alignment. The upper end of the rod 9 extends out of the dome F<sup>1</sup> and is provided with any suitable means for depressing the same, while the upper ends of rods 11 and 12 rest against the lower sides of partitions 2 and 3 respectively. 13 is a cap adapted to snugly fit the top end of the tube D and held against the lower side of the partition 1 by the upper end of rod 10. M is a free space between the filter E<sup>2</sup> and the top of chamber B.

The chamber C is charged with alkali peroxide, preferably sodium peroxide or a mixture of sodium peroxide and potassium tetroxide, and also chamber B is charged with alkali peroxide and tube D is filled with water. The partitions 1, 2, 3, 4 and the rods 9, 10, 11, 12 are brought into the position shown, the said partitions being soldered or otherwise secured in place so that they make an air tight joint and prevent the alkali peroxide in chambers B and C

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from coming into contact with air or moisture, and the water in tube D from evaporating. The apparatus can then be kept ready for use for an indefinite length of time.

When the apparatus has to be used the tube F is connected with the mask or respiration apparatus of the user, such mask or respiration apparatus constituting the breathing space, and then the rod 9 is depressed whereby also the rods 10, 11 and 12 are forced downwards, the partitions 1, 2, 3 and 4 are perforated simultaneously and the cap 13 is driven onto the top end of tube D. The water from the tube D flows through the hole in the partition 3 into the chamber B, where it reacts on the alkali peroxide contained therein so that oxygen is evolved, which escapes through the pipe K, the hole in the partition 4 and tube G into the bag H, it being prevented from escaping through the pipe D by the cap 13 closing the top end of the same.

The air breathed out by the user passes through the tube F and the perforation in the partition 1 into the filter E<sup>1</sup> and thence through the chamber C charged with alkali peroxide, and the filter E<sup>2</sup> into the space M. In the chamber C the above described reaction between the carbonic dioxide and vapour of water contained in the breathed out air, and the alkali peroxide takes place, whereby the breathed out air is enriched in oxygen. The oxygen contained in the bag H serves to compensate for any irregularities in the reaction and breathing and to furnish any oxygen required beyond that supplied by the reaction taking place in the chamber C. On breathing in again, the previously breathed out air enriched in oxygen and thus regenerated goes back through filter E<sup>2</sup> chamber C, and filter E<sup>1</sup>, to the tube F, the last traces of vapour of water and carbonic dioxide being thereby removed with absolute certainty. The filters prevent any particles of alkali peroxide or hydroxide or carbonate from entering into the tube F.

The apparatus just described will permit a person to remain and breath freely in any locality filled with obnoxious or poisonous gases as long as alkali peroxide is contained in the chamber C, but when the alkali peroxide is exhausted, the products of reaction (alkali carbonate and a small quantity of alkali hydroxide) have to be removed from the chamber C, and this chamber has to be filled again with alkali peroxide. This will however be possible only under exceptional conditions; in the majority of cases the receptacle A will be removed and thrown away and replaced by a fresh one, after the contents of the chamber C are exhausted.

The apparatus is very cheap and simple in construction and very efficient and reliable in operation (there being no valves at all in the apparatus), and besides it can be made so light and of so small a volume that it can be carried by a person without interfering with his free movements. Indeed an apparatus of about 3½ lbs in weight will furnish an amount of oxygen sufficient for 40 minutes breathing. Therefore this apparatus will be particularly useful for miners, firemen, and in similar cases.

The construction of the apparatus may be varied without departing from the essence of our invention, thus for instance the chamber B might be dispensed with and the bag H might be filled with oxygen produced independently of our apparatus in any suitable manner, but this would obviously greatly impair the readiness for instantaneous use of the apparatus. Or the bag H and the chamber B might be dispensed with, the charge in the chamber C being so composed of sodium peroxide and potassium tetroxide as to furnish the total amount of the oxygen required for regenerating the breathed out air; but this would be objectionable because the bag H filled with oxygen, besides compensating for any irregularities in the respiration and in the reactions taking place in the chamber C, also serves for equalizing the air pressure in the apparatus during the breathing in and the breathing out periods. Finally the breathed out air after having passed through chamber C might be led back to the tube F

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by a separate pipe, instead of returning to the tube F through the chamber C, suitable valves being provided for compelling the breathed out air to go through chamber C and to return to the pipe F through this separate pipe on breathing in; but this would be objectionable on account of the necessity of using valves which are liable to fail to act properly. 5

We are aware that it has been proposed to regenerate vitiated air by causing pre-determined quantities of alkali peroxide to drop successively into water contained in a closed chamber and by causing the vitiated air to pass through such chamber so that it mixes with the oxygen there produced, the carbonic dioxide contained in such vitiated air being absorbed by the caustic alkali solution formed by the reaction between the alkali peroxide and the water. 10

In contradistinction thereto we cause the breathed out air itself to pass through the alkali peroxide so as to cause the vapours of water and the carbonic dioxide contained therein to act directly upon the alkali peroxide and so to produce the oxygen required for regenerating the breathed out air, totally or in great part by this breathed out air itself. In other words we utilize for regenerating the breathed out air its vitiating elements themselves, thus not only ensuring that these vitiating elements are totally removed with absolute certainty and that an amount of oxygen is always produced by the reaction which exactly corresponds to the quantity of carbonic dioxide and vapour of water contained in the breathed out air thereby rendering the process and apparatus self regulating, but also that the water required for producing oxygen in the case above referred to is dispensed with and all irregularities in the production of oxygen and the regeneration of the vitiated air, connected with the introduction of successive portions of alkali peroxide into the water, are entirely avoided. 15 20 25

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed we declare that what we claim is:—

1. A process for regenerating breathed out air for respiration purposes consisting in causing the breathed out air to pass through a porous layer of alkali peroxide or peroxides and then to return to the breathing space again, substantially as described. 30

2. A process for regenerating breathed out air for respiration purposes consisting in causing the breathed out air to pass through a porous layer of alkali peroxide or peroxides, mixing it with oxygen derived from a separate source and then causing the mixture to return to the breathing space again, substantially as described. 35

3. A process for regenerating breathed out air for respiration purposes consisting in causing the breathed out air to pass through a porous layer of alkali peroxide or peroxides and then to return to the breathing space through the same porous layer of alkali peroxide or peroxides, substantially as described. 40

4. A process for regenerating breathed out air for respiration purposes consisting in causing the breathed out air to pass through a porous layer of alkali peroxide or peroxides mixing it with oxygen derived from a separate source and then causing the mixture to return to the breathing space through the same porous layer of alkali peroxide or peroxides, substantially as described. 45

5. In an apparatus for regenerating breathed out air for respiration purposes the combination of a chamber adapted to be filled with alkali peroxide or peroxides, a tube adapted to connect such chamber at one end to a breathing space, means for normally breaking the communication of such tube with such chamber, means for establishing such communication and a closed space connected to the other end of such chamber substantially as described. 50

6. In an apparatus for regenerating breathed out air for respiration purposes the combination of a chamber adapted to be filled with alkali peroxide or peroxides, a tube adapted to connect such chamber at one end to a breathing 55

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space means for normally breaking the communication of such tube with such chamber means for establishing such communication, a closed space connected to the other end of such chamber, an air tight bag adapted to be connected with such closed space substantially as described.

5 7. In an apparatus for regenerating breathed out air for respiration purposes the combination of a chamber adapted to be filled with alkali peroxide or peroxides, a tube adapted to connect such chamber at one end to a breathing space, means for normally breaking the communication of such tube with such chamber, means for establishing such communication, a closed  
10 space connected to the other end of such chamber, a second chamber adapted to be filled with water, means for normally breaking the communication between this second chamber and the water tube, means for establishing such communication, means for establishing the communication between  
15 the interior of the second chamber and the said closed space and an air tight bag adapted to be connected with such closed space substantially as described.

8. In an apparatus for regenerating breathed out air for respiration purposes the combination of a chamber adapted to be filled with alkali peroxide or peroxides, a tube adapted to connect such chamber at one end to the breathing  
20 space, a filter interposed between such tube and such chamber, means for normally breaking the communication of such tube with such chamber, means for establishing such communication a closed space communicating with the other end of such chamber and a filter interposed between such space and such chamber substantially as described.

25 9. In an apparatus for regenerating breathed out air an alkali peroxide chamber a tube connecting one end of such chamber with the breathing space an air tight transverse partition in such tube between the chamber and the breathing space, means for perforating such partition and a closed space communicating with the other end of such chamber.

30 10. In an apparatus for regenerating breathed out air an alkali peroxide chamber, a tube connecting one end of such chamber with the breathing space, means for breaking and opening such communication, a closed space communicating with the other end of such chamber, a second alkali peroxide chamber, a tube adapted to be filled with water and leading to such second chamber, a  
35 partition between such water tube and the second chamber, means for connecting the second chamber with the closed space, an air tight bag, a partition between such bag and the closed space and means for perforating the said partitions substantially as described.

40 11. In an apparatus for regenerating breathed out air for respiration purposes two alkali peroxide chambers a closed space between them communicating with one end of the upper chamber a tube adapted to be filled with water and leading to the lower chamber such tube being closed at both ends by partitions, a tube connecting one end of the upper chamber to the breathing  
45 space, a partition in such tube, an air tight bag, a partition between such bag and the closed space, a pipe connecting such closed space to the lower chamber, means for simultaneously perforating the said partitions and means for breaking direct communication between the said closed space and the tube leading to the breathing space simultaneously with perforating such partitions substantially as described.

50 12. In an apparatus for regenerating breathed out air for respiration purposes two superposed alkali peroxide chambers a closed space between them and along the lower one of them communicating with one end of the upper chamber a tube adapted to be filled with water and leading to the lower chamber, such tube being closed at both ends by partitions a tube connecting one end of the  
55 upper chamber to the breathing space, a partition in such tube, an air tight bag a partition between such bag and the closed space, a pipe connecting such closed space to the lower chamber a cap adapted to snugly fit the upper end

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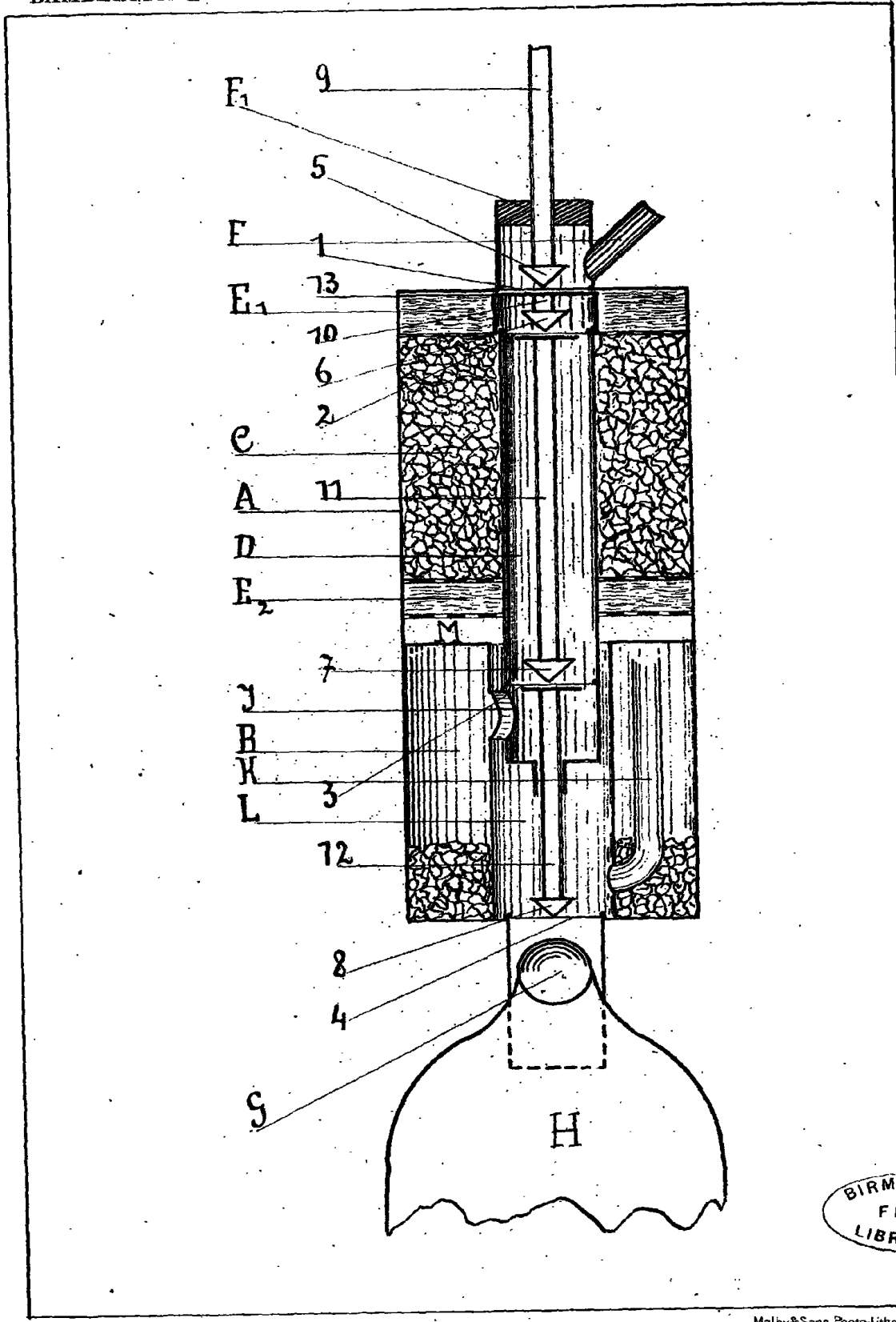
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of the water tube all the said partitions and the cap being in line, and the cap being interposed between the uppermost and the next following partition rods held in line resting with perforating cones at their lower ends against the upper sides of the partitions and with their upper ends against the lower sides of the partitions, and means for depressing the uppermost of these rods, substantially as described. 5

Vienna, the 12th April 1904.

DR. MAX BAMBERGER,  
Professor at the Polytechnical University  
DR. FRIEDRICH BOCK  
Assistant Professor at the Polytechnical University,  
FRIEDRICH WANZ,  
Engineer. 10



[This Drawing is a full-size reproduction of the Original.]

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