Nov. 8, 1938. W. B. DRAPER 2,136,236

MEANS FOR INDICATING PRESENCE AND RELATIVE AMOUNTS OF CARBON DIOXIDE IN GASES FOR BREATHING

Filed April 25, 1936 4 Sheets-Sheet 1

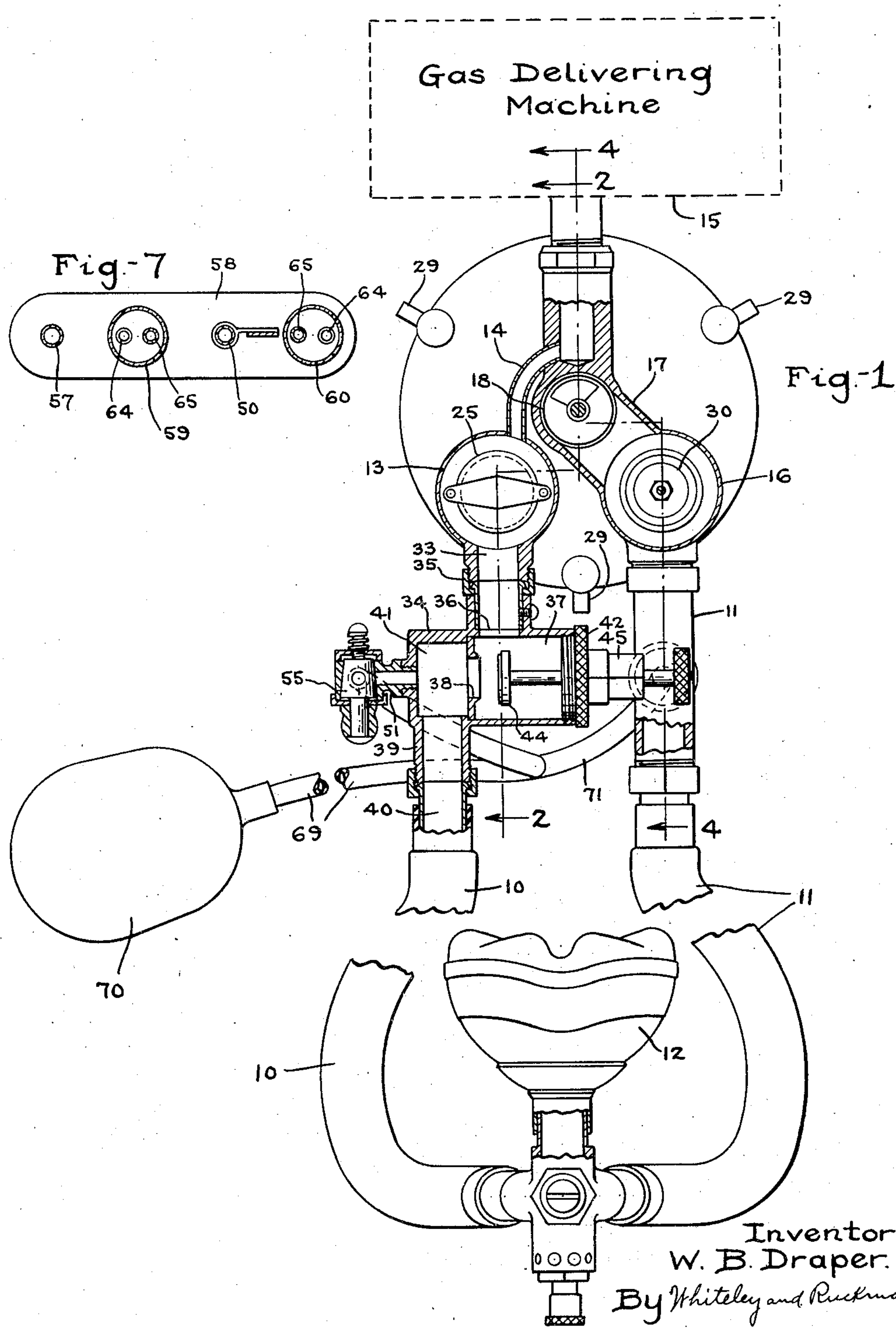

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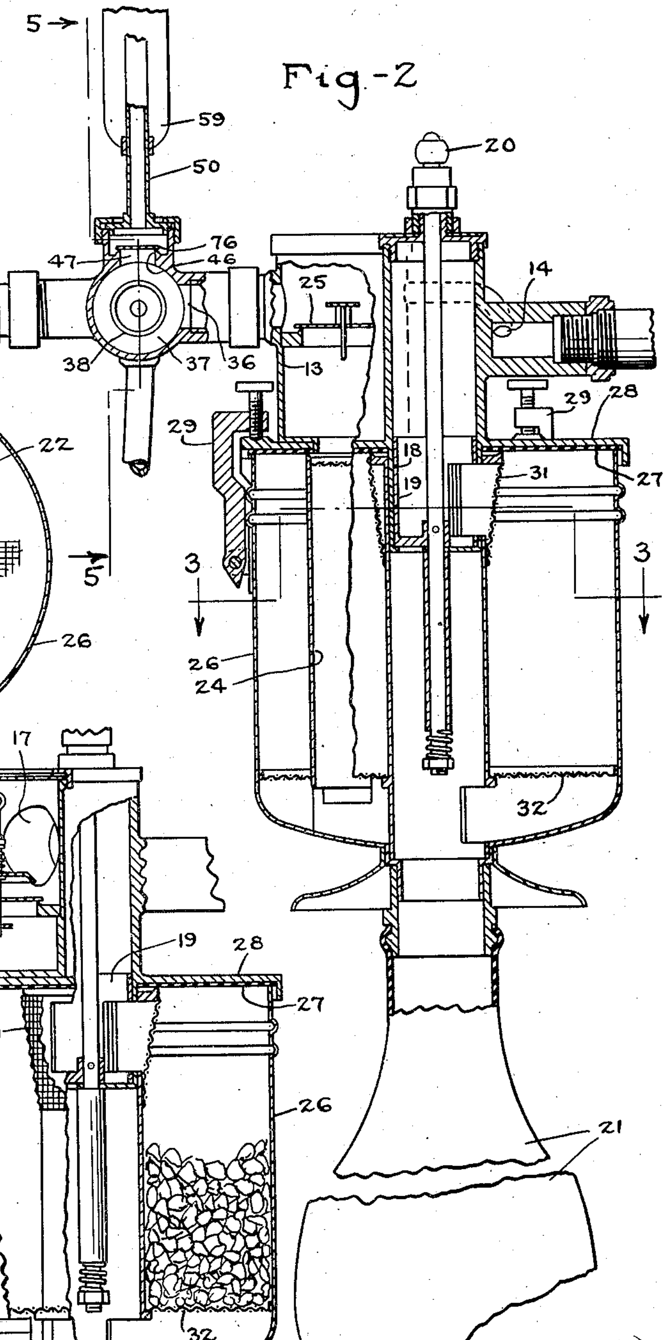
Fig.-2



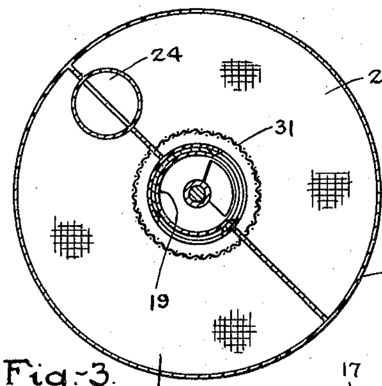


Fig.-3

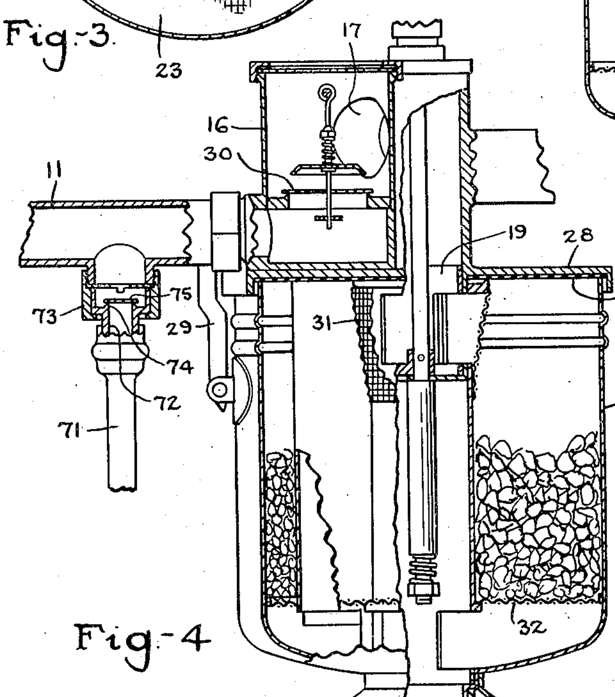


Fig.-4

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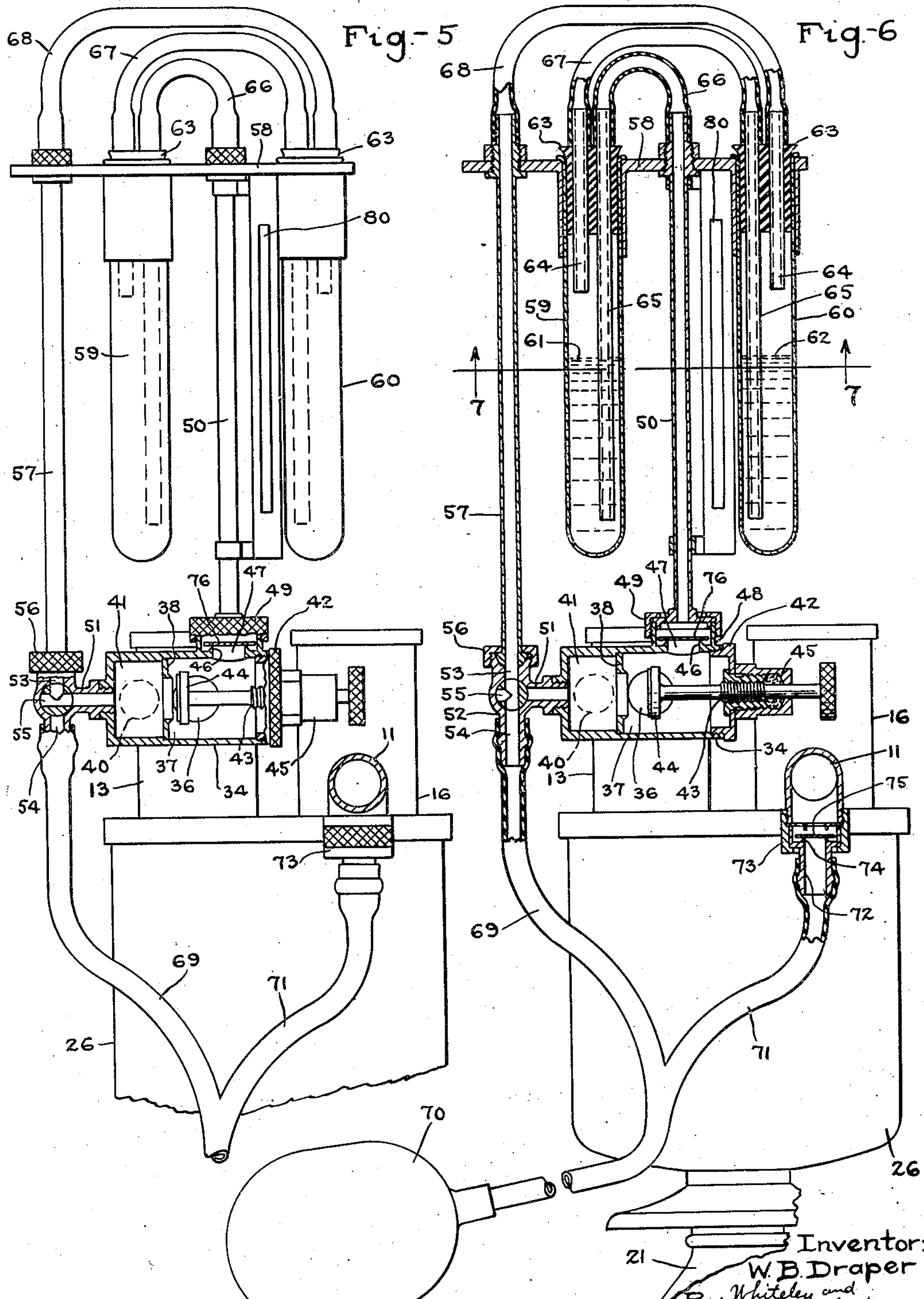
Filed April 25, 1936 4 Sheets-Sheet 3



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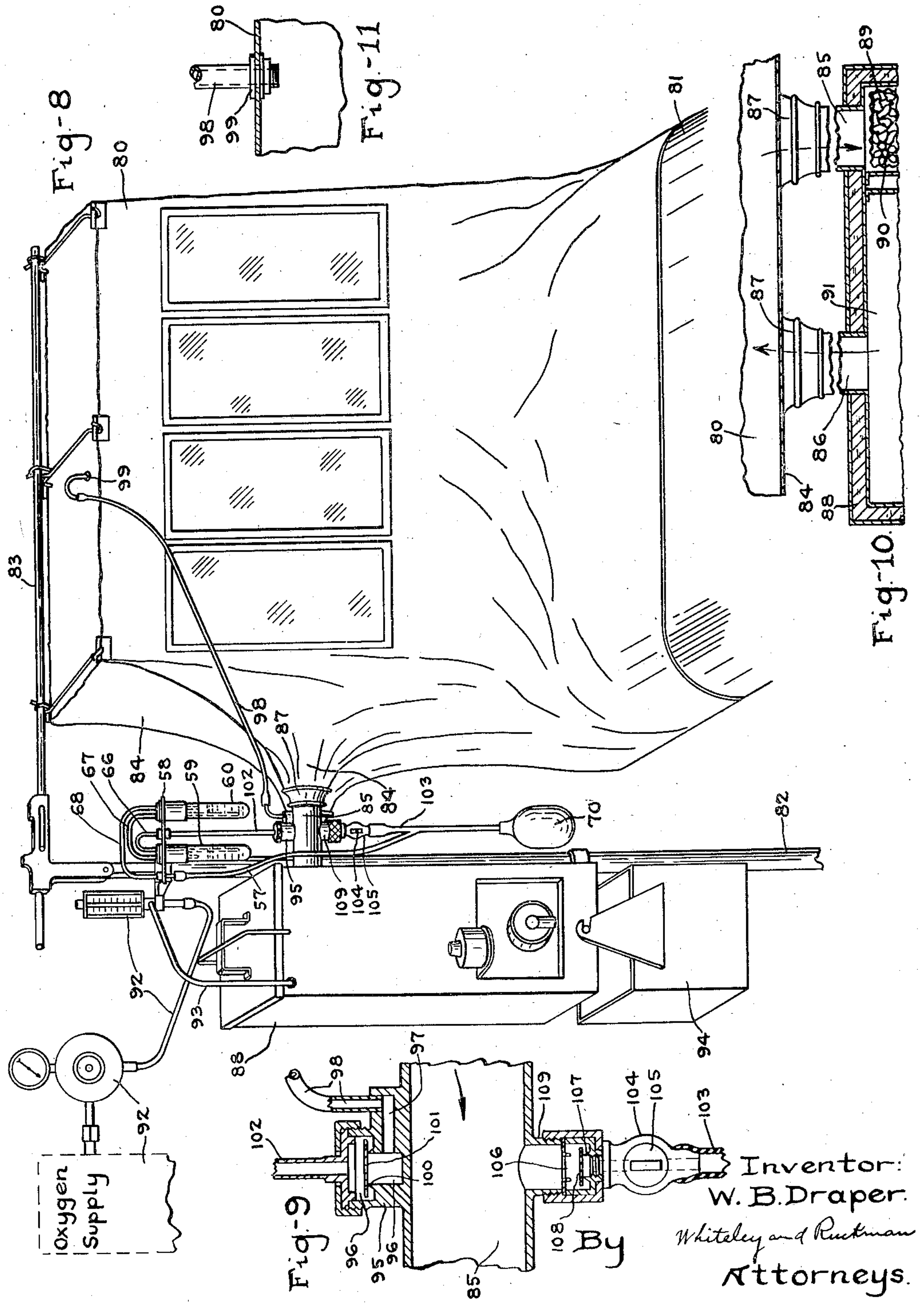
Filed April 25, 1936 4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

2,136,236

MEANS FOR INDICATING PRESENCE AND RELATIVE AMOUNTS OF CARBON DIOXIDE IN GASES FOR BREATHING

William B. Draper, Denver, Colo.

Application April 25, 1936, Serial No. 76,389

9 Claims. (Cl. 128—203)

My invention relates to means for indicating presence and relative amounts of carbon dioxide in gases breathed by patients, and has for its particular object to detect excess carbon dioxide in a gas mixture which the patient is called upon to breathe.

The breathing of mixture in which there may be excess carbon dioxide may take place in connection with gas administering devices for producing anaesthesia or analgesia and in breathing enclosures such as tents and hoods wherein mixtures of air and oxygen and of treated air may be delivered to the patient.

The present technique of administering gases for anaesthesia or analgesia provides for breathing in a closed cycle with means in the breathing circuit to take carbon dioxide from the patient's exhalation, there being added only sufficient gas or gas mixture to replace the elements absorbed in the patient's lungs and tissues. Experience has shown that better results are obtained with this technique than where exhaled gases go to atmosphere or to a rebreathing bag and fresh gas is continually supplied in larger quantities. It is of great importance that the anaesthetist always be advised whether the absorber mechanism is sufficiently removing carbon dioxide gas so that there may never be more than a permissible maximum of such gas in the material going to the patient. It is an object of my invention, therefore, to provide means associated with gas-administering mechanism employing absorber means, such, for example, as that shown in the application of Jay A. Heidbrink, Serial Number 37,497, filed August 23, 1935, for indicating with certainty to the anaesthetist from time to time while the machine is administering gas for anaesthesia or analgesia the condition of the gas going to the patient as regards its CO_2 content.

It is a further object of my invention to provide means of freeing such gas from soda lime dust or acid content before making the test on the carbon dioxide content.

The technique of employing treated air or mixtures of air and oxygen in connection with a hood or tent also calls for breathing in a closed circuit and embodies means for removing carbon dioxide from the current of air which is caused to be withdrawn from the tent or hood at one point and returned to the tent or hood at another point after passing through soda lime absorber mechanism, and, where desired, over ice containers or other refrigerating means. It is an object of my invention to provide means associated with such a closed circulation through a tent or hood for indicating with certainty to the anaesthetist at such times as he may desire to check on the matter the condition of the gas mixture going to the patient in this closed circuit as regards presence therein of CO_2.

It is a further object of my invention to provide means whereby either the inhalation efforts of the patient or action of the operator independent of the inhalation of the patient shall cause some of the inhalation gases to by-pass and bubble through liquid in one or more containers, which liquid shall have the properties of indicating the presence of carbon dioxide and of freeing the gas prior to such indication from soda lime dust or other extraneous matter.

The full objects and advantages of my invention will appear in connection with the detailed description thereof, and its novel features are particularly pointed out in the claims.

In the drawings, illustrating an application of my invention in one form,—

Fig. 1 is a plan view with some parts broken away and in section of absorber mechanism attached to a gas delivering machine such as that shown in the apparatus of the above-noted Heidbrink application. Fig 2 is a sectional side elevation view of said machine taken on line **2—2** of Fig. 1. Fig. 3 is a sectional plan view taken on line **3—3** of Fig. 2. Fig. 4 is a sectional elevation taken on line **4—4** of Fig. 1. Figs. 1, 2 and 4 show my improvements applied to the aforesaid Heidbrink absorber mechanism. Fig. 5 is a side elevation view partly in section along line **5—5** of Fig. 2. Fig. 6 is a similar view with more parts in section and some of the parts in different position. Fig. 7 is a view taken on line **7—7** of Fig. 6. Fig. 8 is a part perspective elevation view of an oxygen tent and the mechanism associated therewith, with my invention applied thereto. Fig. 9 is a side sectional elevation view along the return passageway from the oxygen tent and through a part of the valve mechanism connecting my improvements therewith. Fig. 10 is a horizontal fragmentary sectional view showing the two passageways leading to and from the tent to the box containing the absorber and cooling mechanism. Fig. 11 is a fragmentary elevation view partly in section on an enlarged scale showing the connection of the passageway for withdrawing samples of gases from the tent.

As shown, in the structure of Figs. 1 to 7 inclusive the breathing line comprises inhale side **10** and exhale side **11** from respirator **12**, inhale side **10** drawing through valve chamber **13** which communicates by duct **14** with a gas mixing and delivering machine indicated diagrammatically at 15. The exhale passage 11 on the exhale side of the breathing circuit passes through valve chamber 16 and passageway 17 to absorber valve chamber 18, which is provided with valve mechanism 19 controlled by handle 20 whereby the exhaled gases may be passed directly to rebreathing bag 21 or through either one or the other of absorber chambers 22 and 23 and from there through duct 24 into valve chamber 13 and past valve 25 to inhale passages 10. Absorber container 26, which forms the independent material container chambers 22 and 23, is adapted to be held in gastight relation against gasket 27 on supporting head 28 means of swing screw clamps 29, and a valve 30 in exhale valve chamber 16 controls flow of exhaled gases through chamber 16. A conical wire gauze partition 31 about valve chamber 18, and a similar gauze partition 32 supporting the soda lime absorber material in chambers 22 and 23 permits flow of exhaled gases through the absorber material or soda lime in said chambers when the valve mechanism 19 is set to provide for such movement of gases, which may be either through one alone or in part through both of chambers 22 and 23.

The above-defined mechanism is, as stated, that of the aforesaid Heidbrink application, and in and of itself forms no part of my invention, which, however, is designed for use in an anaesthetising machine wherein there is a closed breathing circuit with means for passing the exhaled gases through soda lime or other material for removing carbon dioxide from the exhaled gases. I will now describe the attachment which comprises the purifying and indicating means, forming in combination with the closed breathing circuit absorber mechanism the features of my invention.

Upon the nipple 33 leading from the inhale valve chamber 13 and between it and the inhale breathing line 10 I interpose a casing 34 which may embody a packing nut 35. The opening 36 from nipple 33 enters valve chamber 37 in casing 34 at one side of valve seat partition 38, and an extension nipple 39 has its opening 40 (shown in dotted lines in Figs. 5 and 6), leaving chamber 41 on the other side of valve seat partition 38 and connecting with inhale tubing 10 in the closed circuit breathing line. A cap 42 closes the end of chamber 37 and carries the threaded stem 43 of valve member 44 adapted to be positioned a distance greater or less from valve seat 38, or, if desired, to engage said seat and close it. As shown in detail in Fig. 6, the threaded valve stem 43 extends through a packing nut 45 to make it gastight.

The casing 34 is provided on its upper surface with a valve seat 46 surrounding an opening 47 around which is a threaded nipple 48 upon which is mounted by means of clamp nut 49 a tubular standard 50, which may be formed of any desired metal such as copper, brass or aluminum. An extension nipple 51 is secured to the end of casing 34 away from valve stem 43, as shown in detail in Figs. 5 and 6. This member is provided with a T 52 having openings 53 and 54 extending in opposite directions with a valve seat and 3-way valve 55 between them, and upon the part of the T 52 embodying the aperture 53 is securely mounted by means of a clamp nut 56 a tubular extension 57 similar to the tubular extension 50 heretofore described.

Upon the tubular members 50 and 57 is securely mounted a supporting plate 58 upon which are supported a plurality of glass tubes similar to test tubes indicated at 59 and 60, there being two such test tubes shown, although it will be understood that it is within the scope of my invention to support any desired greater or less number of such test tubes as conditions of use may indicate. Within the test tubes a suitable amount of liquid is placed, as, for example, water in test tube 59 having its level indicated at 61 and any suitable indicating solution with its level indicated at 62. The test tubes 59 and 60 are closed at their upper ends by rubber stoppers 63 through which extend short tubes 64 opening above the liquid levels 61 and 62 and long tubes 65, which have their lower ends extended into said liquid to near the bottoms of said tubes. A rubber tube 66 connects tubular member 50 with long tube 65 in test tube 59. Similarly a rubber tube 67 connects short tube 64 in test tube 59, with long tube 65 in test tube 60, and a rubber tube 68 connects the short tube 64 in test tube 60 with the tubular standard 57.

Upon the nipple including the opening 54 on the T 52 is mounted a rubber tube 69 which is connected with a compression bulb 70 and also with a branch tube 71 which in turn is connected with a nipple 72. By means of a clamp nut 73 the nipple 72 and a valve seat 74 therein are connected with the exhale side of the breathing line 11, as clearly shown in Fig. 4. A valve disc 75 on valve seat 74 opens for expulsion of gas from bulb 70 and closes against its inward or suction pull, and a valve disc 76 on valve seat 46 closes against expulsion from bulb 70 and opens to suction.

I will now describe the operation of my above-described mechanism. With the 3-way valve 55 and the valve 44 in the positions of Fig. 5, communication from chamber 41 to tube 69 and bulb 70 is cut off. Also direct communication from duct 36 to duct 40 in the inhale side 11 of the breathing line is substantially restricted by valve 44. With the parts in this position the inhalation of the patient will cause a part of the gas of inhalation to move past valve 76 through tube 50 and successively through long tubes 65 and short tubes 64 to bubble through the liquid having levels 61 and 62 successively in test tubes 59 and 60, and thence to pass through tubes 68 and 57 into the inhale side of the breathing line and to the patient.

This will be done at such times as the anaesthetist may desire to have a check on the possible carbon dioxide going into the inhale side of the closed breathing circuit. The bubbling of the inhaled gas through the indicator solution 62 will indicate the amount of CO_2, which may, if desired, be shown on a scale indicated generally at 80, Figs. 5 and 6.

When the parts are in the position of Fig. 6, the patient cannot, of course, draw any gas on inhalation through the tubes and the liquids in the test tubes and will at all times have merely normal breathing conditions for the closed breathing circuit, and the apparatus will be maintained in the position of Fig. 6 at all times excepting when the anaesthetist wishes to check on the possible CO_2 in the inhalation gas. In many cases it may put too much load on the patient's inhalation for the patient himself to draw the gas through the tubes and the solutions, and I have arranged a means for accomplishing this without the intervention of the patient's breathing and without any loss of the gases in the closed circuit breathing line. With the parts as shown in Fig. 6, if the bulb 70 is compressed the valve 76 will prevent gas going into the inhale side and the valve 75 will permit the gas expelled from the bulb to go into the exhale side of the breathing circuit. Upon releasing the bulb the opposite result will take place. The valve 75 will close communication with the exhale side and the valve 76 will permit the bulb to suck gas from the inhale side and draw it through the tube connections to bubble through the liquids in the tubes, whereby the operator can obtain the desired information at any time. The bulb 70 will be made large enough so ordinarily a single compression and expansion will draw enough gas through the indicating liquids to give the desired information and, of course, it is always possible for the anaesthetist to repeat the operation as many times as he may desire.

In the form of my invention in Figs. 10 and 11, an oxygen tent 80 of usual construction is shown supported above the head of a bed 81 by a standard 82 and a support 83 carried thereby. As shown in Fig. 10 a wall 84 of the tent 80 is provided with passages 85 and 86 united with the wall 84 by expanded couplings 87. A conditioning box 88 is provided with a soda lime chamber 89 through which mixture from one end of the tent is caused to move through passageway 85 by a suitable motor, not shown, the air passing through the soda lime 90 in chamber 89 and over ice or other refrigerating means not shown in chamber 91 and back to the tent through passageway 86. Oxygen is supplied in desired amount in a well-known way from supply mechanism indicated generally by the numeral 92, the oxygen entering the soda lime chamber through pipe 93. A suitable container 94 is provided below the box 88 to receive the drip from the melting ice in the ice chamber therein. The above arrangement is or may be an oxygen tent arrangement, in common use, and is illustrated of means for furnishing treated air to patients by a closed circuit passing through the box or cabinet embodying the treating means. In general the arrangement is the same where a hood is employed in place of an oxygen tent, and in either case my invention will be applied thereto in the same manner as herein described.

As shown in Figs. 8 and 9, the passageway 85 embodies a valve housing 95 forming a valve chamber 96, and the lower part of the chamber 96 connects through a passageway 97 and tubing 98 with the top of the tent, as indicated at 99 in Figs. 8 and 11. This portion of valve chamber 96 is surrounded with a valve seat 100 adapted to be closed by check valve disc 101. From chamber 96 extends a standard 102 which supports a system of indicators and connecting tubes exactly as shown in detail in Figs. 5 and 6 and heretofore described. In this form the tubing 57 goes directly to the bulb 70 without the intervention of a shut-off valve. The bulb 70, as in Figs. 8 and 9, connects by tubing 103 with valve casing 104 which embodies a shut-off valve 105 and includes a valve chamber 106 opening into passageway 85, valve seat 107 and valve disc 108, as shown in Fig. 9. By these means, through compression of bulb 70 gas may be drawn through tubing 98 from within the tent or hood and pass through the indicator tubes 59 and 60 and then discharge back into the circuit through valve casing 109 surrounding the valve chamber 106.

Various solutions may be employed as indicators in the tubes 59, 60 acting in a well-known way to give the desired indication through changes in color of the solution. I have found that superior results may be secured by using a solution of brom cresol purple in a solution of calcium carbonate. The calcium carbonate functions as a buffer. An alkaline buffer serves to regulate the pH of the solution, so that its concentration may be varied as desired according to working conditions, and such variations in buffer concentration make possible the attainment of various pH strengths with the same concentration of CO_2 moving in the closed circuit of the anaesthetizing machine or of the oxygen tent. A practically universal solution may employ a seventy-five per cent saturated solution of calcium carbonate. When this strength of buffer is used one and one-half per cent of CO_2 in the gases produces a reddish purple in the indicator. As the percentage of CO_2 in the gases rises the pH of the solution falls, and with a CO_2 concentration of four per cent the indicator becomes yellow. Although solutions of other salts may be used as a buffer, I prefer to use calcium carbonate because it is easily prepared, because it is low-priced, because it is resistant to change on standing, and because it is relatively resistant to significant change by contamination with soda lime or tap water, which is a matter to be considered because of the possible varied operating conditions under which the solution will be used. I prefer to use brom cresol purple as the indicator because it gives a color change which is rapid and definite enough to be easily detected, and because its color change is over a pH range particularly suited to regulation by variation of the buffer concentration.

The advantages of my invention will be apparent from the foregoing description. By means of a very simple attachment or addition to a standard gas anaesthetizing machine employing CO_2 absorber means and a closed circuit to pass exhalation gases through said absorber or to an oxygen tent or hood through which a closed circuit of gases treated and to be breathed is passed, the anaesthetist may quickly and readily at any time check on inhalation gases to determine whether CO_2 in the inhalation gases going to the patient is in excess of a permissible maximum. If the indication shows that there is an excess of CO_2, immediate correction may be made. In the case of the gas administering machine this may be effected by the anaesthetist shifting the valve mechanism 19 controlling flow of exhalation gases through the absorbing material to produce greater absorption, or, if required, temporarily to throw out of operation the absorber while absorber material is being replenished therein and open the breathing line to permit exhalations to go to atmosphere or direct to the re-breathing bag with additional supplies of fresh gas from the gas mixing machine. In tests made where employed in connection with the oxygen tent, correction may be made by adding more oxygen and changing the soda lime in the soda lime container, and, if desired, by evacuating the tent of its gas mixture content.

Hence, by the means herein described, danger to the patient from incomplete absorption of CO_2 in a closed breathing circuit and the presence of excess amounts of CO_2 therein may be effectively and certainly avoided.

I claim:

1. In an apparatus for subjecting individuals to a breathing mixture in a closed breathing circuit wherein gases are caused to move through the closed circuit by the patient's breathing, means

adapted to have connection with said closed circuit for indicating the presence of CO_2 in the mixture within the closed breathing circuit which is breathed by the patient, and means for causing a sample of said mixture to pass through the indicating means.

2. In an apparatus for subjecting individuals to a breathing mixture in a closed breathing circuit wherein the gases are caused to move through the closed circuit by the patient's breathing, a container enclosing a solution for indicating the presence of CO_2 mixture within the closed breathing circuit which is breathed by the patient, said container having a transparent portion through which said solution is visible, and means for causing a sample of said mixture to pass into the container and bubble through said solution.

3. In anaesthetizing apparatus embodying CO_2 absorber mechanism and a closed breathing circuit adapted to pass exhalations through said absorber mechanism and thence on inhalation to the patient, a valve chamber in the inhalation line, a by-pass for said inhalation gases, valve means associated with said valve chamber for rendering said by-pass operative to pass inhalation gases therethrough or inoperative, and CO_2 indicating means in said by-pass.

4. In anaesthetizing apparatus embodying CO_2 absorber mechanism and a closed breathing circuit adapted to pass exhalations through said absorber mechanism and thence on inhalation to the patient, a valve chamber in the inhalation line, a by-pass for said inhalation gases, valve means associated with said valve chamber for rendering said by-pass operative to pass inhalation gases therethrough or inoperative, means in the by-pass for cleaning inhalation gas going therethrough from dust and extraneous material, and means in the by-pass for thereafter indicating the presence of CO_2 in the inhalation gas.

5. An apparatus embodying means for delivering to individuals a breathing mixture in a closed breathing circuit, a container enclosing an indicating solution, said container having a transparent portion through which said solution is visible, and means including a valve and a suction device under the control of the operator for causing said breathing mixture in its circuit to bubble through said solution.

6. In anaesthetizing apparatus embodying CO_2 absorber mechanism and a closed breathing circuit adapted to pass exhalations through said absorber mechanism, a container embodying an indicating solution with a transparent portion through which said solution is visible, a by-pass passageway for passing inhalation gases through said solution, and means including a compression bulb controlled by the operator for moving inhalation gases through the by-pass.

7. In anaesthetizing apparatus embodying CO_2 absorber mechanism and a closed breathing circuit adapted to pass exhalations through said absorber mechanism, a container embodying an indicating solution with a transparent portion through which said solution is visible, a by-pass passageway for passing inhalation gases through said solution, means including a compression bulb controlled by the operator for moving inhalation gases through the by-pass, and means to close the by-pass to the bulb and open it to the patient's inhalation.

8. In anaesthetizing apparatus embodying CO_2 absorber mechanism and a closed breathing circuit adapted to pass exhalations through said absorber mechanism, a container embodying an indicating solution with a transparent portion through which said solution is visible, a by-pass passageway for passing inhalation gases through said solution, a passageway connecting said by-pass with the exhale side of the breathing circuit, check valves in said by-pass and last-named passageways, and a compression bulb connected with said last-named passageway whereby compression of the bulb will force inhalation gases into the exhalation side of the breathing circuit and subsequent expansion of the bulb will draw inhalation gases through said by-pass.

9. In an apparatus for subjecting individuals to a breathing mixture in a closed breathing circuit wherein the gases are caused to move through the closed circuit by the patient's breathing, a container enclosing a solution, including an indicator and a buffer consisting of an absolute metallic salt, for indicating the presence of CO_2 mixture within the closed breathing circuit which is breathed by the patient, said container having a transparent portion through which said solution is visible, and means for causing a sample of said mixture to pass into the container and bubble through said solution.

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