

W. E. TULLAR.
 APPARATUS FOR PRODUCING ARTIFICIAL RESPIRATION.
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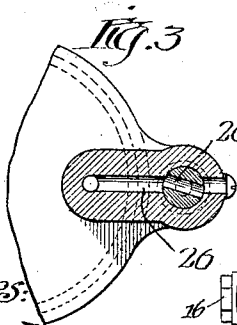
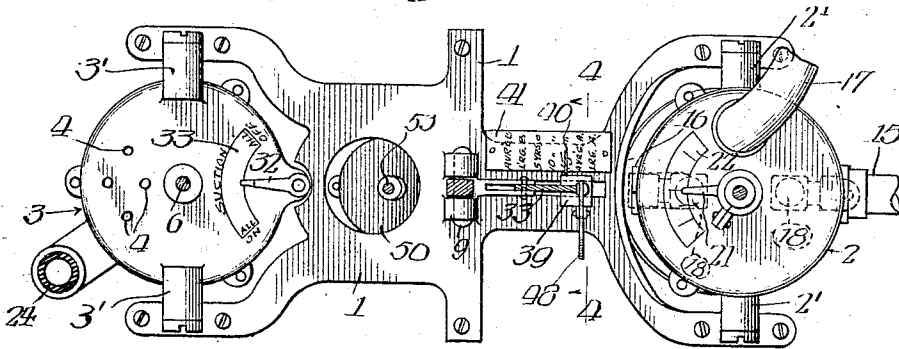
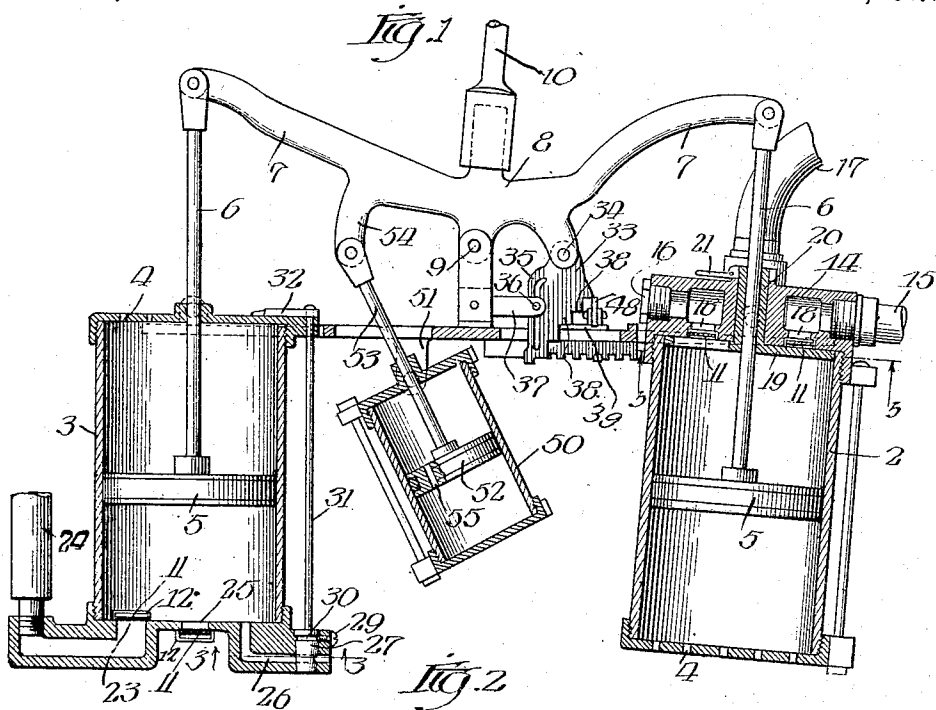
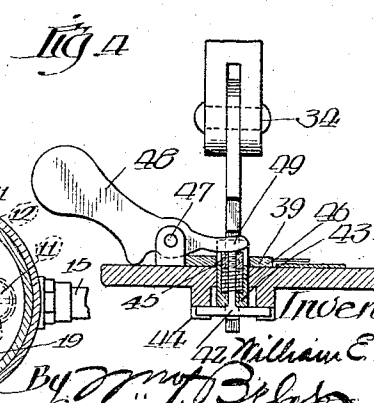


Fig. 5.



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UNITED STATES PATENT OFFICE.

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APPARATUS FOR PRODUCING ARTIFICIAL RESPIRATION.

1,213,302.

Specification of Letters Patent.

Patented Jan. 23, 1917.

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To all whom it may concern:

Be it known that I, WILLIAM E. TULLAR, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Apparatus for Producing Artificial Respiration, of which the following is a specification.

This invention relates to an apparatus for producing artificial respiration whereby air or oxygen or mixtures thereof may be forced into and carbon-dioxid or other waste products withdrawn from the lungs of a patient alternately, the purpose being to simulate and thereby stimulate spontaneous breathing where respiration has ceased owing to asphyxiation or other causes.

More specifically the invention relates to an improved form of the apparatus disclosed in my copending application, Serial No. 40,559, filed July 19, 1915.

Medical authorities differ as to the advisability of applying suction to the lungs of a patient to withdraw carbon-dioxid and other waste products therefrom in the method of inducing respiration by artificial means and in any event it is extremely desirable that the degree of suction exerted on the lungs may be varied at will or that the suction be eliminated in particular cases.

It is the principal object of my invention to provide an apparatus for producing artificial respiration in which the degree of suction exerted by the apparatus on the lungs of a patient may be varied or the suction may be entirely eliminated without interfering with the operation of that portion of the mechanism provided to supply oxygen-containing gas to the lungs of a patient.

A further object of my invention is the provision in an apparatus of the above-described character of means for regulating the speed of operation, means for simultaneously varying the effective capacity of the oxygen-containing-gas-supplying and waste-product-withdrawing means and means for varying the proportion of oxygen in the oxygen-containing gas supplied to the patient.

Other objects and advantages of my invention will be apparent as it is better understood by reference to the following specification when read in connection with the accompanying drawing in which—

Figure 1 is a vertical section through an

apparatus according to my invention; Fig. 2 is a plan view, partially in section, of the structure illustrated in Fig. 1; Fig. 3 is a horizontal section on the line 3—3 of Fig. 1; Fig. 4 is a vertical section on the line 4—4 of Fig. 2 and Fig. 5 is a section on the line 5—5 of Fig. 1.

Referring to the drawing, 1 indicates a suitable frame at either end of which the cylinders 2 and 3 are pivotally mounted by means of trunnions 2' and 3', the cylinder 2 constituting means for supplying oxygen-containing gas to the lungs of a patient and the cylinder 3 constituting means for withdrawing waste and other products from the lungs of a patient. Within the cylinders 2 and 3, each of which is freely open to the atmosphere at one end as indicated at 4, are pistons 5 connected by rods 6 to the oppositely directed arms 7 of a member 8 pivotally mounted at 9 on the frame 1 and provided with an operating handle 10. Obviously when the member 8 is rocked on its pivot 9 the pistons 5 are reciprocated in the cylinders 2 and 3.

Each of the cylinders 2 and 3 are provided with valved inlets and outlets, preferably controlled by disk valves 11 of mica or other suitable material, each retained in position by wires 12. These valves are extremely light and sensitive and are, therefore, operable by the lungs of a patient even when in exhausted condition.

The upper end of the cylinder 2 comprises a head 14 chambered to provide three ducts or passages, one of which is adapted to receive a supply of oxygen from a suitable source through a tube 15, another to receive air through an inlet 16 and the other constituting an outlet leading to the pipe 17 which delivers the oxygen-containing gas to the mouth and nose-piece of usual construction. The oxygen and air-receiving ducts deliver the gas through inlets 18 to the cylinder 2 and the inlets 18 are, therefore, provided with disk valves 11 so arranged that the valves are opened when the piston 5 moves downwardly in the cylinder 2. The duct leading to the pipe 17 is provided with a similar valve but oppositely disposed so that it opens as the piston 5 moves upwardly in the cylinder 2, the valves in the inlets 18 being closed at this period of the operation. In order that oxygen and air may be mixed in any desirable propor-

tion I provide a rotatable valve 19 secured to a sleeve 20 surrounding the rod 6 and co-operating with the inlets 18 to the cylinder 2 so that as the valve 19 is rotated the inlets 18 are proportionately opened or closed.

5 An operating member 21 is secured to the upper end of the sleeve 20 and an indicator 22 is mounted on the cylinder head 14 to coöperate with the operating member 21 and indicate the position of the rotatable valve 19.

10 It will be understood from the foregoing description that I am enabled to allow oxygen or air alone or mixtures thereof in any proportion to enter the cylinder 2 and that this mixture will be forced from the cylinder 2 through the pipe 17 to the mouth and nose-piece during the operation of the apparatus.

20 The inlet 23 at the lower end of the cylinder 3 is connected by a pipe 24 to the mouth and nose-piece and the disk valve 11 is so disposed that it is opened when the piston 5 is traveling upwardly in the cylinder 3. Carbon-dioxid and other waste products are thereby drawn through the pipe 24 into the cylinder 3. The outlet 25 in the bottom of the cylinder 3 is also provided with a valve 11 but arranged to open when the piston 5 travels downwardly in the cylinder 3 whereby the products withdrawn from the lungs are driven from the cylinder. Because in particular cases it may be undesirable to subject the lungs of a patient to suction I provide means whereby the degree of suction may be varied or the suction entirely eliminated while the means for supplying oxygen-containing gas remains in operation. The best way of accomplishing this purpose is, as I have discovered, to vary the effective capacity of the suction cylinder 3 since obviously the degree of suction is proportionate to the effective capacity of the cylinder. By admitting more or less air to the cylinder 3 as the piston 5 rises therein the effective capacity of the cylinder may be varied at will and any degree of suction between that possible with the apparatus and no suction at all may be readily provided. I, therefore, arrange a duct or bleeder 26 at the base of the cylinder 3 and opening into the interior thereof and to the atmosphere. A valve plug 27 is disposed in a suitable valve seat and is provided with an opening 28 which, when disposed in alinement with the duct 26, allows air to pass into the cylinder 3 as the piston 5 rises therein. The valve plug 27 is held in proper position in its seat by a screw 29 engaging a groove 30 in the plug 27 and an operating rod 31 is connected to the plug 27 and to an arm 32 at the upper end of the cylinder 3.

65 The arm 32 coöperates with a scale 33 on the cylinder head which indicates the posi-

tion of the opening 28 in the valve plug with respect to the duct 26. By operating the arm 32 the effective capacity of the cylinder 3 and hence the degree of suction may be varied as desired. When the valve plug 27 is turned to a position in which the opening 28 registers with the duct 26 substantially no suction will be produced in the pipe 24 whereas if the opening 28 in the valve plug 27 is so disposed as not to register with the duct 26 the suction produced by the cylinder 3 in the pipe 24 will be at a maximum. When no suction is produced by the cylinder 3 in the pipe 24 the patient exhales by contraction of the lungs through the pipe 24 to the cylinder 3 and thence directly to the atmosphere through the outlet 25 and the duct 26. As previously stated the disk valves 11 are so sensitive that no effort on the part of the patient is required to operate them.

The lungs of persons of different sizes vary in capacity and it is desirable, therefore, that the quantity of air or oxygen supplied be carefully measured and remain constant throughout the operation of the apparatus. This result is accomplished by the provision of a sector 33 pivotally secured at 34 to the member 8 and slotted at 35 to engage a pin 36 on an arm 37 projecting from the frame 1. As the member 8 rocks the sector 33 reciprocates vertically. The sector 33 is provided, with a plurality of steps 38 adapted to selectively engage a member 39 slidably mounted on the frame 1 and provided with an indicator 40 coöperating with the scale 41, indicating different capacities of the cylinders 2 and 3. A T-shaped member 42 is slidably mounted in a depending portion 43 of the member 39 and is adapted to selectively engage teeth 44 formed on the underside of the frame 1. A collar 45 is secured to the upper end of the T-shaped member 42 and the spring 46 is disposed between the collar 45 and a shoulder formed on the depending portion 43 of the member 39. Pivotally mounted at 47 on the member 39 is a manually operable lever 48, the end 49 of which is disposed in engagement with the collar 45 and by operating the lever 48 the T-shaped member 42 may be depressed against the spring 46 to free it from the teeth 44 so that it may be adjusted to engage one or the other of the steps 38 on the sector 33.

To limit the speed of operation of the apparatus so that the patient can not be injured I provide a cylinder 50 pivotally secured to lugs 51 depending from the frame 1 and adapted to contain a fluid such as castor oil which has the advantage of not varying in viscosity to any extent at usual temperatures. A piston 52 is disposed within the cylinder 50 and connected by a rod 53 to an arm 54 on the member 8 so that as the

member 8 rocks the piston 52 reciprocates within the cylinder 50. The piston 52 is provided with a restricted opening 55 which allows the fluid to pass from one side to the other of the piston 52 as it reciprocates. 5 The fluid being incompressible it will be apparent that the speed of operation of the piston 52 and hence of the member 8 depends on the rate of flow of the fluid through the restricted opening 55. The size of the 10 opening 55 is designed to allow the flow of fluid with sufficient rapidity to permit the apparatus to be operated at a speed sufficient to supply oxygen-containing gas 2 and 15 withdraw waste products from the lungs of a patient at the normal rate of breathing.

It will be understood from the foregoing that I have perfected an apparatus in which the effective capacity of the waste-product-withdrawing means is variable independently of the effective capacity of the oxygen-containing-gas-supplying means so that suction may be exerted in varying degrees upon the lungs of a patient or may be eliminated 25 entirely.

My apparatus further provides means for simultaneously varying the effective capacity of the cylinders 2 and 3 whereby the apparatus is adjusted to the lung capacity of a 30 patient.

Finally my machine provides means to limit the rate of speed at which it may be operated and means to vary the proportion of oxygen in the oxygen-containing gas supplied. I have, therefore, provided an apparatus of the greatest utility and wide application as means for resuscitating patients where respiration has ceased. 35

It will be apparent that various changes may be made in the form, construction and arrangement of the parts without departing from the spirit and scope of the invention or sacrificing any of its material advantages, the form hereinbefore described being merely 40 a preferred embodiment thereof.

I claim:

1. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately 50 close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, and means whereby said waste-product withdrawing means may be rendered inoperative while said oxygen-containing-gas-supplying means continues in operation. 55

2. In an apparatus of the character de-

scribed, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, valves in said 70 inlets and outlets, means whereby said waste-product-withdrawing means may be rendered inoperative while said oxygen-containing-gas-supplying means continues in operation, and means for preventing the operation of said first-mentioned means beyond a predetermined rate of speed. 75

3. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said inlets and outlets, and adapted to alternately 80 close said inlets and outlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means whereby said waste-product-withdrawing means may be rendered inoperative while said oxygen-containing-gas-supplying means continues in operation, and means for varying the effective capacity of 90 said first-mentioned means. 95

4. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said inlets and outlets, and adapted to alternately 100 close said inlets and outlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means whereby said waste-product-withdrawing means may be rendered inoperative while said oxygen-containing-gas-supplying means continues in operation, and means for varying the proportion of oxygen in the oxygen-containing gas supplied. 105 115

5. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, valves in said inlets and outlets, means whereby said waste-product-withdrawing means may be rendered inoperative while said oxygen-containing-gas-supplying means continues in 120 operation, means for preventing the operation of said first-mentioned means beyond a predetermined rate of speed, and means for varying the effective capacity of said first-mentioned means. 125 130

6. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said inlets and outlets, and adapted to alternately close said inlets and outlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means whereby said waste-product-withdrawing means may be rendered inoperative while said oxygen-containing-gas-supplying means continues in operation, means for varying the effective capacity of said first-mentioned means, and means for varying the proportion of oxygen to the oxygen-containing gas supplied.

7. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, valves in said inlets and outlets, means whereby said waste-product-withdrawing means may be rendered inoperative while said oxygen-containing-gas-supplying means continues in operation, means for preventing the operation of said first-mentioned means beyond a predetermined rate of speed, and means for varying the proportion of oxygen-containing gas supplied.

8. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, and means whereby one of said cylinders may be rendered inoperative while the other remains in operation.

9. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, valves in said outlets and inlets, means whereby one of said cylinders may be rendered inoperative while the other remains in operation, and means for preventing the operation of said pistons beyond a predetermined rate of speed.

10. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means whereby one of said cylinders may be rendered inoperative while the other remains in operation, and means for varying the effective capacity of said cylinders.

11. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means whereby one of said cylinders may be rendered inoperative while the other remains in operation, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

12. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, valves in said outlets and inlets, means whereby one of said cylinders may be rendered inoperative while the other remains in operation, means for preventing the operation of said pistons beyond a predetermined rate of speed, and means for varying the effective capacity of said cylinders.

13. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus,

means whereby one of said cylinders may be rendered inoperative while the other remains in operation, means for varying the effective capacity of said cylinders, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

14. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, valves in said outlets and inlets, means whereby one of said cylinders may be rendered inoperative while the other remains in operation, means for preventing the operation of said pistons beyond a predetermined rate of speed, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

15. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said inlets being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, and means for varying the effective capacity of said waste-product-withdrawing means independently of the effective capacity of said oxygen-containing-gas-supplying means.

16. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, valves in said outlets and inlets, means for varying the effective capacity of said waste-product-withdrawing means independently of the effective capacity of said oxygen-containing-gas-supplying means, and means for preventing the operation of said first-mentioned means beyond a predetermined rate of speed.

17. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means for varying the effective capacity of

said waste-product-withdrawing means independently of the effective capacity of said oxygen-containing-gas-supplying means, and means for simultaneously varying the effective capacity of said first-mentioned means.

18. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means for varying the effective capacity of said waste-product-withdrawing means independently of the effective capacity of said oxygen-containing-gas-supplying means, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

19. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, valves in said outlets and inlets, means for varying the effective capacity of said waste-product-withdrawing means independently of the effective capacity of said oxygen-containing-gas-supplying means, means for preventing the operation of said first-mentioned means beyond a predetermined rate of speed, and means for simultaneously varying the effective capacity of said first-mentioned means.

20. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means for varying the effective capacity of said waste-product-withdrawing means independently of the effective capacity of said oxygen-containing-gas-supplying means, means for simultaneously varying the effective capacity of said first-mentioned means, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

21. In an apparatus of the character described, the combination of means for supplying oxygen-containing gas to and with-

drawing waste and other products from the lungs of a patient, an outlet from and an inlet to each of said means, valves in said outlets and inlets, means for varying the effective capacity of said waste-product-withdrawing means independently of the effective capacity of said oxygen-containing-gas-supplying means, means for preventing the operation of said first-mentioned means beyond a predetermined rate of speed, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

22. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, and means for varying the effective capacity of the waste-product-withdrawing cylinder independently of the effective capacity of the oxygen-containing-gas-supplying cylinder.

23. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, valves in said outlets and inlets, means for varying the effective capacity of the waste-product-withdrawing cylinder independently of the effective capacity of the oxygen-containing-gas-supplying cylinder, and means for preventing the operation of said pistons beyond a predetermined rate of speed.

24. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means for varying the effective capacity of the waste-product-withdrawing cylinder independently of the effective capacity of the oxygen-containing-gas-supplying cylinder, and means for simultaneously varying the effective capacity of said cylinders.

25. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means for varying the effective capacity of the waste-product-withdrawing cylinder independently of the effective capacity of the oxygen-containing-gas-supplying cylinder, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

26. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, valves in said outlets and inlets, means for varying the effective capacity of the waste-product-withdrawing cylinder independently of the effective capacity of the oxygen-containing-gas-supplying cylinder, means for preventing the operation of said pistons beyond a predetermined rate of speed, and means for simultaneously varying the effective capacity of said cylinders.

27. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for actuating said pistons, an outlet from and an inlet to each of said cylinders, a disk of relatively light material loosely maintained in bodily movable relation to each of said outlets and inlets, and adapted to alternately close said outlets and inlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, means for varying the effective capacity of the waste-product-withdrawing cylinder independently of the effective capacity of the oxygen-containing-gas-supplying cylinder, means for simultaneously varying the effective capacity of said cylinders, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

28. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, pistons therein, means for ac-

tuating said pistons, an outlet from and an inlet to each of said cylinders, valves in said outlets and inlets, means for varying the effective capacity of the waste-product-withdrawing cylinder independently of the effective capacity of the oxygen-containing-gas-supplying cylinder, means for preventing the operation of said pistons beyond a predetermined rate of speed, and means for varying the proportion of oxygen in the oxygen-containing gas supplied.

29. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, an inlet and an outlet from each of said cylinders, pistons in said cylinders, means for actuating said pistons whereby suction is produced in one and pressure in the other cylinder, a disk of relatively light material loosely maintained in bodily movable relation to each of said inlets and outlets and adapted to alternately close said inlets and outlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, a bleeder to the suction cylinder, and means for controlling said bleeder to vary the effective capacity of the cylinder.

30. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, an inlet and an outlet from each of said cylinders, pistons in said cylinders, means for actuating said pistons whereby suction is produced in one and pressure in the other cylinder, a disk of relatively light material loosely maintained in bodily movable relation to each of said inlets and outlets and adapted to alternately close said inlets and outlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, a duct leading to the interior of the suction cylinder and communicating with the atmosphere, a valve in said duct, and means for operating said valve to vary the effective capacity of the cylinder.

31. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a plurality of cylinders, an inlet and an outlet from each of said cylinders, pistons in said cylinders, means for actuating said pistons whereby suction is produced in one and

pressure in the other cylinder, a disk of relatively light material loosely maintained in bodily movable relation to each of said inlets and outlets and adapted to alternately close said inlets and outlets, the weight of said disks being such that they are readily operable by the lungs of the patient to permit spontaneous breathing through the apparatus, a duct leading to the interior of the suction cylinder and communicating with the atmosphere, a valve in said duct, means for operating said valve to vary the effective capacity of the cylinder, an indicator scale secured to the exterior of the suction cylinder, and an indicator secured to said valve-operating means and cooperating with said scale.

32. In an apparatus of the character described, the combination of a supporting frame, means for supplying oxygen-containing gas to and withdrawing waste-products from the lungs of a patient, an inlet to and an outlet from each of said means, valves in said inlets and outlets, means for actuating said first-mentioned means, and means for limiting the movement of said actuating means comprising a toothed sector, a member slidably mounted on said frame, a plurality of teeth on said frame, a member pivotally mounted on said slidably mounted member, and means actuated thereby and adapted to selectively cooperate with the teeth on said frame whereby said slidably mounted member is adjustably disposed with respect to said toothed sector.

33. In an apparatus for supplying oxygen-containing gas to and withdrawing waste and other products from the lungs of a patient, the combination of a supporting frame, a pair of cylinders, pistons therein, means for actuating said pistons, an inlet to and an outlet from each of said cylinders, valves in said inlets and outlets, and means for varying the stroke of said pistons comprising a sector pivotally connected to said actuating means and provided with a plurality of stepped teeth, a member slidably mounted on said frame, a plurality of teeth on said frame, a member pivotally mounted on said slidably mounted member, and means actuated thereby and adapted to selectively cooperate with the teeth on said frame whereby said slidably mounted member is adjustably disposed with respect to said sector.

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