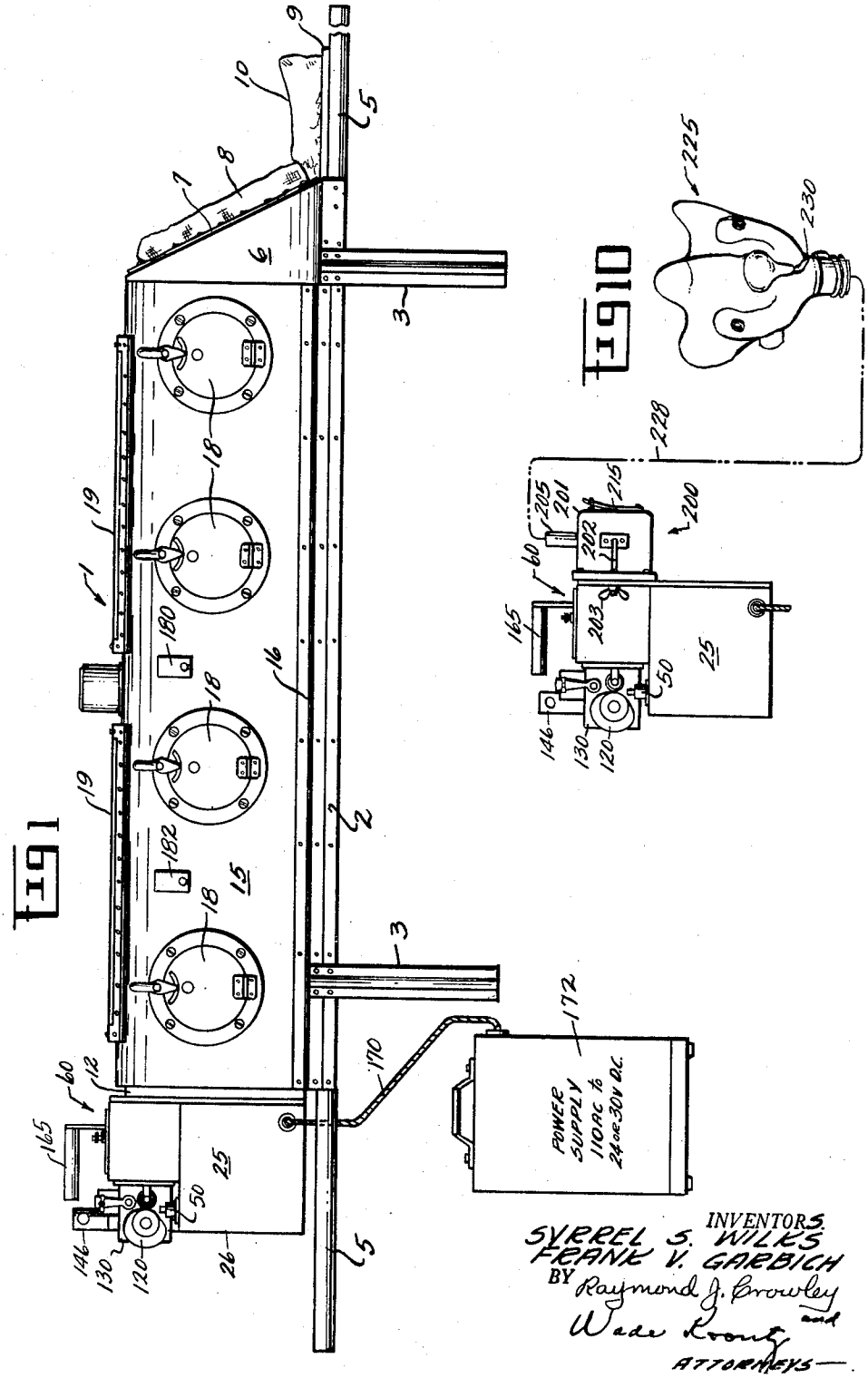
Jan. 8, 1957 S. S. WILKS ET AL 2,776,659

RESPIRATORY APPARATUS

Filed Jan. 26, 1954 5 Sheets-Sheet 1



INVENTORS
SYRREL S. WILKS
FRANK V. GARBICH
BY Raymond J. Browley and Wade Kroutz
ATTORNEYS

Jan. 8, 1957 S. S. WILKS ET AL 2,776,659

RESPIRATORY APPARATUS

Filed Jan. 26, 1954 5 Sheets-Sheet 2

Fig 11

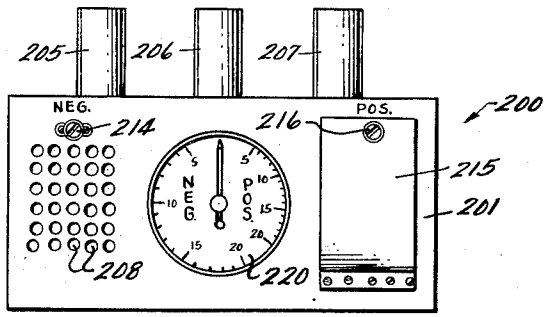
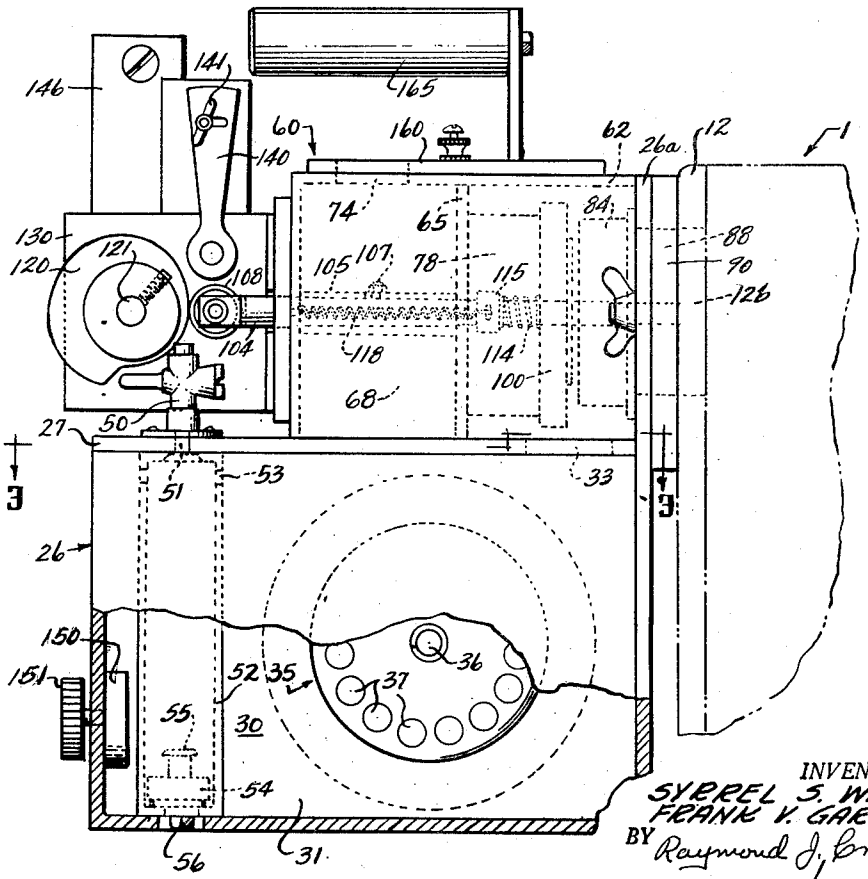


Fig 2



INVENTORS.
SYRREL S. WILKS
FRANK V. GARBICH
BY Raymond J. Crowley
and
Wade Koontz
ATTORNEYS

Jan. 8, 1957 S. S. WILKS ET AL 2,776,659

RESPIRATORY APPARATUS

Filed Jan. 26, 1954 5 Sheets-Sheet 3

Fig 3

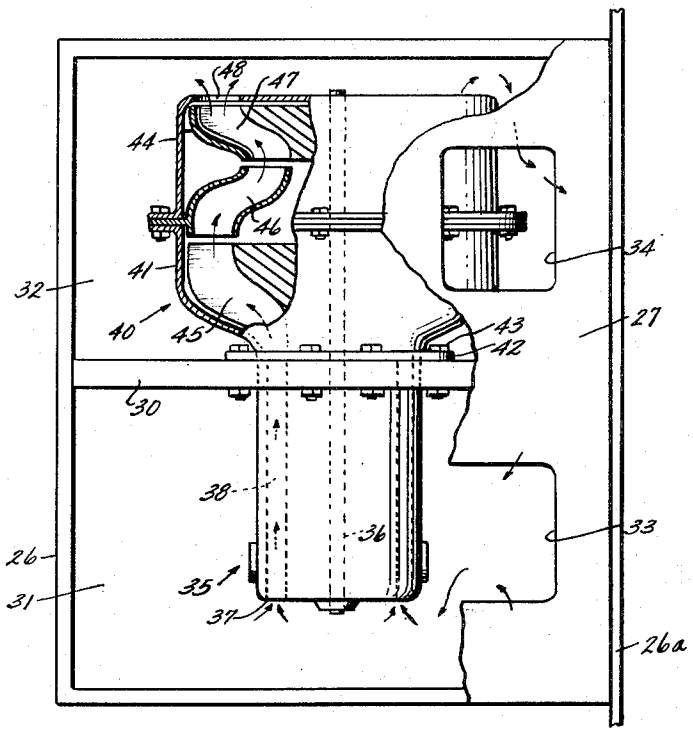
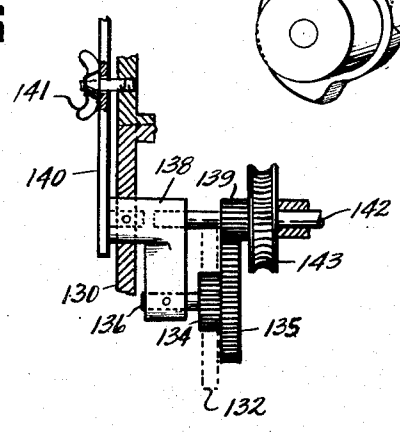


Fig 6



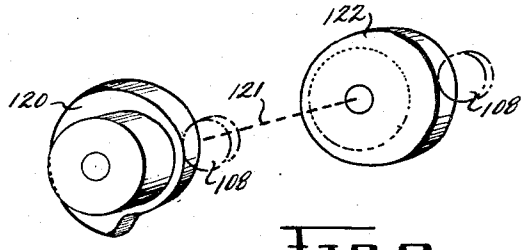


Fig 9

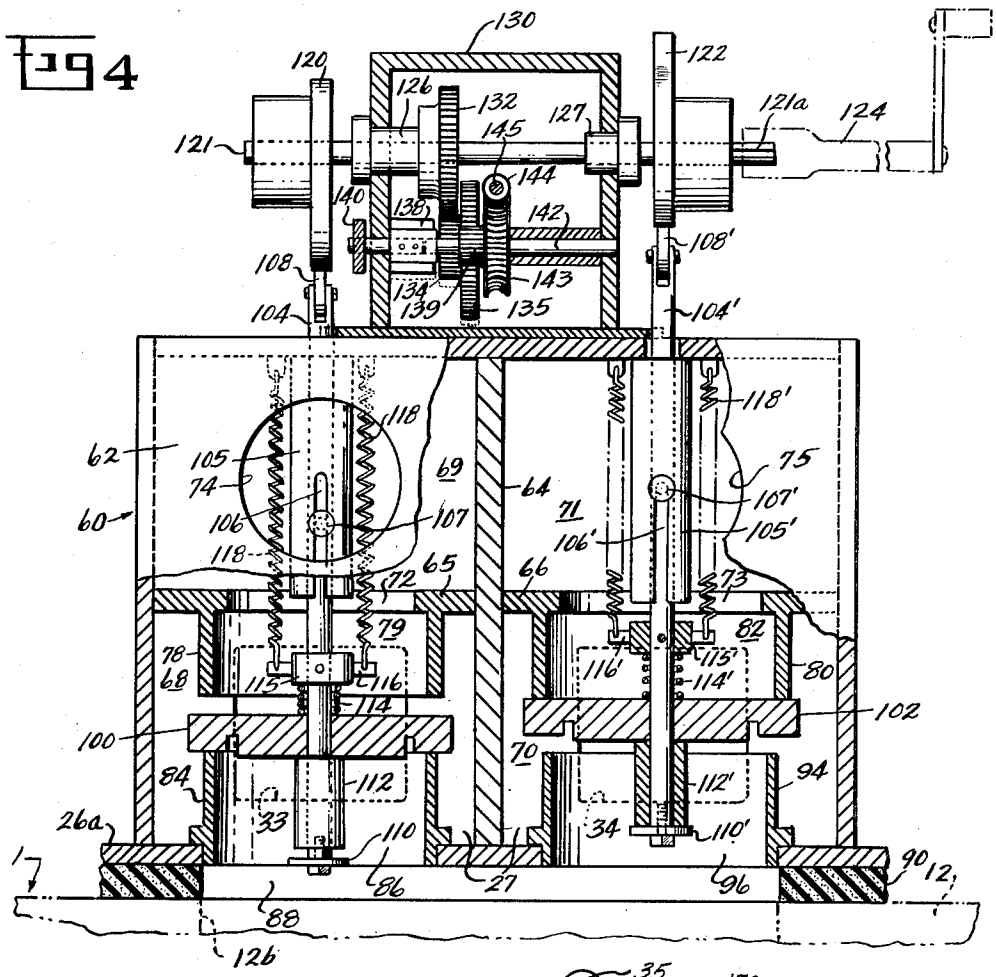
INVENTORS
SYRREL S. WILKS
FRANK V. GARBICH
BY Raymond J. Crowley
Wade Koontz and
ATTORNEYS

Jan. 8, 1957 S. S. WILKS ET AL 2,776,659

RESPIRATORY APPARATUS

Filed Jan. 26, 1954 5 Sheets-Sheet 4

Fig 4



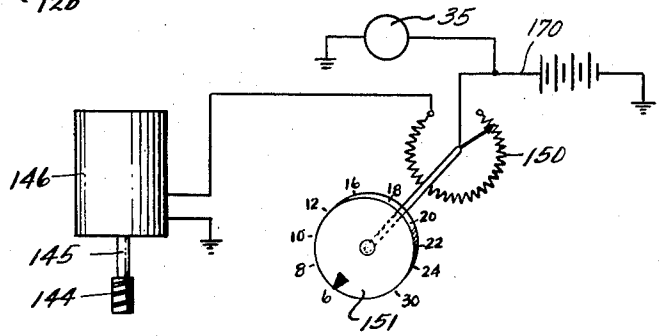


Fig 7

INVENTORS
SYRREL S. WILKS
FRANK V. GARBICH
BY Raymond J. Crowley
Wade Kronk and
ATTORNEYS

Jan. 8, 1957 S. S. WILKS ET AL 2,776,659

RESPIRATORY APPARATUS

Filed Jan. 26, 1954 5 Sheets-Sheet 5

Fig 195

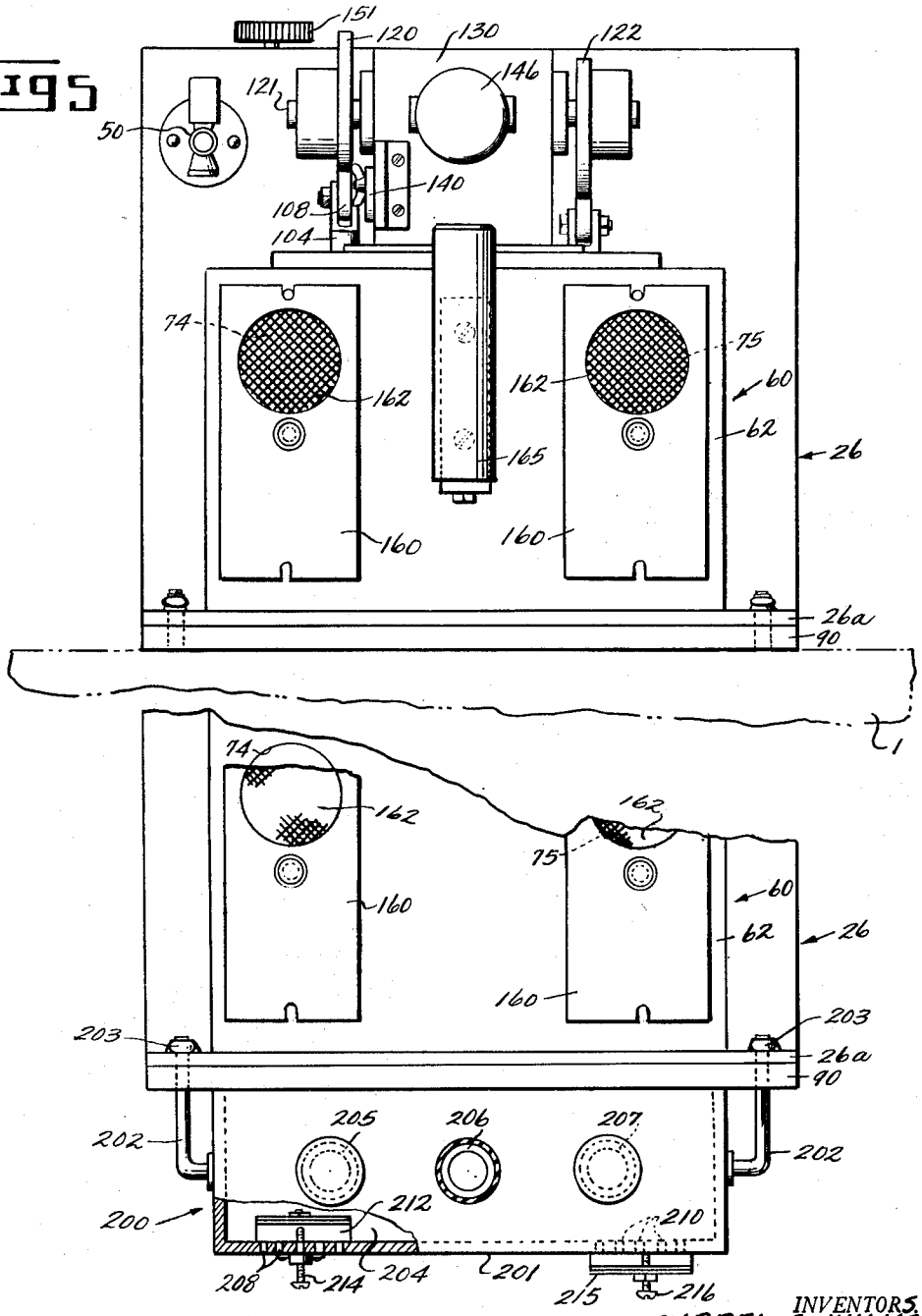


Fig 198

INVENTORS
SYRREL S. WILKS
FRANK V. GARBICH
BY Raymond J. Crowley
and
Wade Kenty
ATTORNEYS

United States Patent Office 2,776,659 Patented Jan. 8, 1957

2,776,659

RESPIRATORY APPARATUS

Syrrel S. Wilks, San Marcos, and Frank V. Garbich, San Antonio, Tex., assignors to the United States of America as represented by the Secretary of the Air Force

Application January 26, 1954, Serial No. 406,369

8 Claims. (Cl. 128—30)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without payment to us of any royalty thereon.

This invention relates to an improved light weight respirator particularly adapted for the transport of polio patients by aircraft. A respirator in accordance with the invention provides a light weight shell forming a respirator chamber enclosing the body of the patient and having an external head rest and a flexible plastic sealing collar of conventional construction. The respirator housing is provided with litter handles for carrying the patient into the aircraft and suitable supports. A self contained device for alternately creating positive and negative pressures in the respirator housing is provided which includes a direct current motor driven blower and power driven cam actuated valving which connects the inlet side of the blower to the chamber to create a negative pressure therein to cause inflation of the patient's lungs and then to connect the outlet side of the blower to the respirator chamber to create a positive pressure therein to cause exhalation. The cams which control the valving are driven through reduction gearing by an adjustable speed direct current motor to thereby adjust the rate of the respiratory cycle. Air bleed controls are provided on the respirator housing to control the magnitude of the positive and negative pressures in the chamber and the blower capacity is such that a large volume of air is drawn in and expelled from the chamber ventilating and cooling the patient's body and eliminating objectionable odors which would arise if a closed system were employed. The system also provides for creating a continuous suction which can be employed as an aspirator in conjunction with an intratrachial catheter to withdraw mucus and fluids from the throat of the patient. The self contained blower and valve mechanism may also be employed in conjunction with a conventional oxygen mask as an automatic resuscitator.

Other features of the invention will become apparent by reference to the detailed description hereinafter given and to the appended drawings in which:

Fig. 1 is a view showing a respirator constructed in accordance with the invention and energized from an external power supply and;

Fig. 2 is a side view, partly in section illustrating the valve and blower assembly.

Fig. 3 is a top view partly in section taken on line 3—3 of Fig. 2.

Fig. 4 is a top plan view of the valve mechanism and gear housing, partly in section.

Fig. 5 is a top plan view of the valve and blower assembly.

Fig. 6 is a fragmentary view illustrating details of a cam driving gear train;

Fig. 7 is a schematic wiring diagram of the power supply system.

Fig. 8 is a top plan view partly in section of the valve assembly with the resuscitator unit attached.

Fig. 9 is a perspective view of cams employed in the invention.

Fig. 10 is a side elevation of the valve and blower assembly used with a mask as a resuscitator.

Fig. 11 is a front elevation of the resuscitator manifold.

Referring now to Fig. 1 the respirator generally indicated by the reference numeral **1** comprises a light weight metal frame and bottom structure **2** which provides a bed support for the patient. The frame **2** is provided with vertical legs **3** for supporting the respirator on the floor and with four handle extensions **5** which enable the entire assembly to be carried like a litter.

At one end of the frame **2** there is secured a fixed housing head **6** made of aluminum alloy sheet or other light weight material which is semi-circular in cross section and provided with a slanting end wall **7** provided with an aperture, not shown, for emergence of the patient's head and neck. The end wall **7** is provided with a conventional flexible neck seal **8** and a hinged plate **9** which supports a pillow **10** for the patient's head.

At its other end the frame **2** has a vertical end wall **12** of semi-circular cross section. A lid generally indicated by the reference numeral **15** and made of thin aluminum alloy sheet material is formed with a semi-circular cross-section and is hinged along one edge as indicated at **16** to frame **2**. The lid **15** is adapted to be clamped along its other longitudinal edge by means not shown to the frame **2**. The lid **15** is provided with suitable sponge rubber gaskets not shown which engage with the head **6** and end wall **12** when the lid **15** is clamped down to minimize air leakage.

The lid **15** is provided with conventional access doors **18** along each side and with transparent viewing windows **19** on its top for viewing the patient. The lid **15** when folded back on its hinge **16** permits a patient to be placed in the respirator after which the lid **15** is closed and clamped with the patient's head and neck projecting through the sealing collar **8** and the head resting on the pillow **10**.

A self contained valve and blower assembly generally indicated by the reference numeral **25** includes a blower housing **26** and a valve housing **60** secured thereto and having a valve actuating assembly **130** secured on the front side thereof. A handle **165** is provided for carrying the valve and blower assembly when disassembled from the respirator end wall **12**.

As seen in Figs. 2 and 3 the blower housing **26** which is in the form of a rectangular box is provided on its upper side with a cover **27** which serves as a mounting for the valve assembly housing **60**. The housing **26** is provided with a centrally disposed longitudinally extending partition wall **30** which divides the housing into two chambers **31** and **32**. The chamber **31**, called the vacuum chamber, communicates by means of a port **33** in the cover **27** with the interior of the valve housing **60** and similarly the chamber **32**, known as the pressure chamber communicates by means of a port **34** in the cover **27** with the interior of the valve housing **60**.

The wall **30** of housing **26** is suitably apertured to receive the housing of a high speed series wound D. C. motor generally indicated by the reference numeral **35**. The motor **35** has an armature shaft **36** journalled in the end bell of the housing which is provided with a series of ports **37** which communicate with chamber **31** and allow air from the chamber to pass through cooling passages **38** (Fig. 3) in the stator of the motor **35**, to cool and ventilate the motor. The cooling passages **38** also conduct air into the inlet of a two stage blower generally indicated by the reference numeral **40**.

The blower **40** is provided, as seen in Fig. 3, with a casing portion **41** which is provided with a mounting flange **42** which is fastened by bolts **43** to the partition

wall 30 and also serves to mount the motor 35. The blower 40 is also provided with a second casing portion 44 which provides a bearing for the outer end of the motor shaft 36 which drives the blower 40.

Also as seen in Fig. 3 the blower 40 is provided with a first stage centrifugal waved impeller 45 which is driven by the motor shaft 36 and receives air at its inlet from the cooling passages 38 of motor 35. The output of air under pressure from impeller 45 passes through the inward flow stationary guide vanes 46 into the inlet of the second stage centrifugal impeller 47 which also is driven by the motor shaft 36. The blower output passes from the second stage impeller 47 through ports 48 in the casing element 44 directly into the pressure chamber 32 of the housing 26 and passes by way of port 34 into the interior of valve housing 60.

The motor 35 which is of the series wound direct current type operates on direct current of from 24 to 30 volts and rotates under load at speeds from 15,000 to 20,000 R. P. M. With the motor 35 and blower 40 in operation negative or suction pressure of 30 cm. or more of water will prevail in inlet chamber 31 and a similar positive pressure of 30 or more cm. of water will prevail in the pressure chamber 32. The continuous sub-atmospheric pressure existing in chamber 31 is utilized for an aspirator which as seen in Fig. 2 comprises an aspirator line cock 50 mounted on the cover plate 27 and adapted to be connected to an external fluid trap not shown which in turn is connected by a flexible tubing to an intratrachial catheter which can be used to withdraw fluids and mucus from the patient's throat. The cock 50 communicates by means of a passage 51 with the upper end of a cylindrical container 52 positioned within the chamber 31. The interior of container 52 communicates by means of ports 53 with the chamber 31 so as to normally create a suction in passage 51 and aspirator cock 50 when the cock is opened and connected to an aspirator tubing not shown. If the external fluid trap not shown, completely fills with fluid, the overflow will enter the container 52. A float 54 is provided in the container 52 which will rise and by means of a valve 55 mounted thereon will shut off passage 51 to prevent the fluids from flowing over through ports 53 into the chamber 31. A removable drain plug 56 is provided for draining any fluids collected in container 52.

As seen in Fig. 2 the valve assembly includes a valve housing 60 of rectangular shape, the rear vertical wall 26*a* of which is formed by an extension of the corresponding end wall of the blower housing 26. The valve housing 60 is open on its bottom and is secured to the cover plate 27 of housing 26. The valve housing 60 is provided with a cover plate 62.

As seen in Fig. 4, the valve housing is provided on its interior with a longitudinally extending partition wall 64 and transverse partition walls 65 and 66 which divide the valve housing 60 into four chambers respectively indicated by reference numerals 68, 69, 70 and 71. A circular passage 72 affords communication between chambers 68 and 69 and a similar passage 73 connects chambers 70 and 71. Chamber 69 is normally open to the atmosphere by means of a port 74 formed in the valve housing cover plate 62 and a similar port 75 connects chamber 71 to the atmosphere. The chamber 68 communicates by means of port 33 in the cover plate 27 with the suction chamber 31 of the blower housing 26 and similarly the chamber 70 of the valve housing communicates by means of the port 34 in cover plate 27 with the pressure chamber 32 of the blower housing 26.

The passage 72 is encircled by an annular valve seat 78 providing a passage 79 for flow from chamber 69 through passage 72 into chamber 68. A similar annular valve seat 80 formed on the partition wall 66 encircles the passage 73 and provides a passage 82 for flow from chamber 71 through passage 73 into the chamber 70.

An annular valve seat 84 provides a flow passage 86 interconnecting the chamber 68 by means of an aperture 88 in a sealing gasket 90 and a registering aperture 12*b* in the end wall 12 of the respirator 1 of Fig. 1 to the interior of the respirator. Similarly an annular valve seat 94 provides a flow passage from chamber 70 to the interior of the respirator by way of gasket aperture 88 and the aperture 12*b* in the respirator end wall 12.

The annular valve seats 78 and 84 are axially aligned and spaced apart at their inner ends to cooperate with a circular double seating poppet valve 100. Similarly the annular valve seats 80 and 94 are axially aligned and spaced apart at their inner ends to cooperate with a similar double seat poppet valve 102.

Since the means for actuating the valves 100 and 102 are identical only one means will be described and corresponding parts of the other actuating means are indicated by the same reference numerals primed. The valve 100 is slidably mounted on a valve rod 104 which in turn is slidable in a valve guide bushing 105 secured to the front wall of the valve housing 60. The bushing 105 is slotted at 106 and cooperates by means of a pin 107 to prevent the valve rod from turning in the valve guide bushing 105. At its outer end the valve rod is provided with a cam follower roller 108.

At its outer end the valve rod 104 is provided with a washer 110 which engages a slidable spacer bushing 112 which engages the rear side of the valve 100 to move the valve in one direction. On the opposite side of the valve 100 a compression spring 114 encircles the valve rod 104 and at one end contacts the valve face and at its opposite end engages a collar 115 pinned to the valve rod 104. The collar 115 is provided with lateral extensions 116 which serve as anchorages for one end of a pair of retraction springs 118 which are anchored at their outer ends to the front wall of valve housing 60.

When valve 100 is moved by the actuating rod or valve stem 104 to the position shown in Fig. 4, the valve will move with the rod 104 until the face of the valve seats on the annular valve seat 84. Any further movement or over travel of the valve rod 104 merely causes the collar 115 to further compress the spring 114. When the actuating force is removed from valve rod 104, the retraction springs 118 pulls the collar 115 and valve rod 104 in the upward direction as seen in Fig. 4. The spring 114 then elongates and when the washer 110 engages the bushing 112 the valve 100 will be lifted from the valve seat 84 and will continue in motion until it engages the valve seat 78.

Movement of the valve 100 in the direction to seat the valve on valve seat 84 is effected by means of a cam 120 which engages the follower roller 108 and it is returned to seat on valve seat 78 by the force of retraction springs 118. The provision for overtravel of the valve rod 104 after the valve is seated ensures proper valve seating and simplifies the tolerances which would otherwise be necessary. The cam 120 controls the positive pressure part of the respiratory cycle and is mounted on one end of a cam shaft 121, a corresponding cam 122 being mounted on the opposite end of the cam shaft 121 and actuating cam follower roller 108^1 and valve rod 104^1 to move valve 102 to control the negative pressure part of the respiratory cycle.

The cam shaft 121 is provided with a squared end portion 121*a* on which may be fitted a hand crank 124 (shown in phantom) for rotating the cam shaft manually in case of power failure of the cam driving motor.

As further seen in Fig. 4, the cam shaft 121 is journalled for rotation by means of bearings 126 and 127 in a gear case 130 mounted on the front of the valve housing 60. The cam shaft 121 is adapted to be driven by a gear 132 which meshes with a pinion gear 134 which together with a larger gear 135 form a gear cluster mounted for free rotation on a stud 136 carried in a block 138 which is journalled for rotation in the wall of gear case 130 and adapted to be rocked by an external slotted lever 140 (note Figs. 2 and 6) and locked by a wing nut 141.

The gear **135** (Fig. 4) meshes with a pinion **139** fast on a shaft **142** journalled at one end in the gear housing **130** and at its other end in the block **138** concentric with the rocking axis of the latter (see Fig. 6). A worm gear **143** is also fixed on shaft **142** and meshes with a worm **144** fixed on the lower end of an armature shaft **145** which forms part of an adjustable speed direct current motor **146** mounted on the top of the gear casing **130**, see Fig. 2. The speed of motor **146** can be adjusted to vary the speed of the cam shaft **121** to adjust the respiratory cycle rate from 6 to 30 cycles per minute by means of a rheostat **150** having an indicating and adjusting knob **151**, see Figs. 2 and 7.

When the lever **140** is unlocked and rotated counterclockwise as seen in Figs. 2 and 6 the block **138** is rocked and gear **135** walks around pinion **139** and pinion **134** is unmeshed from driving engagement with gear **132** permitting the cam shaft **121** to be manually rotated by hand crank **124** in case the motor **146** should fail. Rotation of lever **140** in the opposite sense and locking the same permits driving the cam shaft **121** by motor **146** through the gear train, worm **144**, worm gear **143**, shaft **142**, pinion **139**, gear **135**, pinion **134** and gear **132** fixed on shaft **121**.

As seen in Fig. 5, plastic strips **160** are removably secured to the top plate **62** of the valve housing **60** and have filter screens **162** adapted to register with the ports **74** and **75** in the plate **62** and these strips may be reversed in position to block these ports when a manually actuated emergency pulsator pump not shown is employed. A handle **165** is provided for carrying the valve and blower assembly when disassembled from the respirator **1**.

Again referring to Fig. 7 the plug in conductor **170** which connects to both motors **35** and **146** may be connected to an external power supply such as indicated at **172** which may contain a step down transformer and rectifier unit (not shown) adapted to be connected to any convenient source of 110 v. A. C. The plug in conductor **170** may be connected directly to a 25 volt battery or to the similar direct current source on an aircraft.

Operation

After a patient is placed in the respirator **1** (Fig. 1) and conductor **170** plugged in to a source of 24 volts D. C., motors **35** and **146** will be energized and the respirator will begin functioning.

As previously described above when motor **35** is operating air will be drawn in from chamber **31** and passing through motor inlet ports **37** Fig. 2, and motor cooling passages **38** Fig. 3, will pass into the two stage blower **40** and be delivered under pressure to the chamber **32** Fig. 3.

Assuming the valves in the position shown in Fig. 4, air from the ambient atmosphere will enter the port **74**, enter the chamber **69** and pass through passages **72** and **79**, the valve **100** being open and pass into chamber **68**. From chamber **68** the air will flow downward through the port **33** into the chamber **31** Fig. 3, from whence it passes through motor **35** into blower **40** and out ports **48** into chamber **32**. Air under pressure will flow upward from chamber **32** Fig. 3, through port **34** Fig. 4, into the chamber **70**. The valve **102** will be seated as seen in Fig. 4 on valve seat **80** and the air under pressure will flow from chamber **70** through the passage **96** in valve seat **94** and into the apertures **88** and **12***b* and thence into the interior of the respirator and will build up pressure therein. The delivery pressure of the blower **40** is considerably in excess of the desired positive pressure in the respirator **1** and a flap valve **180** is provided in the lid **15** of the respirator **1** see Fig. 1 which allows sufficient flow through the respirator to limit the positive pressure to the order of 30 centimeters of water. The excess flow flushes out stagnant air and odors out of the respirator and ventilates the patient.

When the cam **120** has rotated to the position shown in Fig. 2, the retraction springs **118** will move the valve rod **104** and valve **100** until the latter is seated on valve seat **78**, sealing off the chamber **68** from communication with the atmosphere. Air will then flow through a bleed valve **182** Fig. 1, into the respirator and then through passages **12***b* and **88** from the interior of the respirator and through passage **86** of valve seat **84** into chamber **68**. From chamber **68** it will flow down through port **33** into chamber **31** of Fig. 3. The flow is from chamber **31**, Fig. 3 through motor **35** into blower **40** as previously described. Since the volume of the respirator is fixed, removal of air therefrom reduces the pressure therein below atmospheric pressure and bleed valve **182** is adjusted to allow sufficient inflow from the atmosphere into the respirator, so that the negative pressure is limited to about 30 centimeters of water. Fresh air entering the respirator through the bleed valve **182** is further useful in ventilating the interior of the respirator and cooling the patient.

The valve **102** in the meantime will have moved by actuation of valve rod **104**[1] by cam **122** (Fig. 4) until it seats on annular valve seat **94** blocking communication between the interior of the respirator and chamber **70**. Chamber **70**, however will then be in free communication with chamber **71** and the atmosphere through port **75**. The air under pressure delivered by the blower **40**, Fig. 3 through ports **48** will flow up from chamber **32** through port **34** into chamber **70** of the valve housing and then escape to atmosphere by passing through passages **82**, **73** chamber **71** and port **75** as described above.

It will be noted that the motor **146** is continuously driving the cam shaft **121** at a slow rate of from 6 to 30 R. P. M. giving a corresponding number of complete respiratory cycles. The proper cycling rate is determined by a physician and depends on the age and condition of the patient, children requiring a higher rate than old people. It will be further noted that when cam **120** Fig. 4 engages the roller **108** and moves the valve rod **104** inward valve **100** will seat on valve seat **84** to block communication between the suction side of the blower and the interior of the respirator **1**. Simultaneously the cam **122** allows the retracting springs **118**[1] to move the valve **102** in the opposite direction so as to deliver air from the positive pressure side of the blower **40** to the respirator. The valves are approximately oppositely phased so that when the suction side of the blower is connected to the respirator the positive pressure side is vented to the atmosphere and when the positive pressure side of the blower is connected to the interior of the respirator the negative pressure or inlet is connected to the atmosphere. The fact that the valves are yieldingly mounted on the actuating rods which can overtravel the valve movement in either direction permits a variation in the valve phasing during parts of the cycle. This fact permits the cams to be shaped such as to give the desired rates of positive and negative pressure build up and decay and the duration of the positive and negative pressure portions of the cycle.

The approximate shape of the cams **120** and **122** is shown in Fig. 9, which also shows the phase relation of the cams. The shapes of the cams were determined experimentally to give a cyclic pressure variation in the respirator corresponding to experimentally determined respiration pressures deemed by physiologists as desirable. These cam shapes also provide for valve rod overtravel.

Resuscitator

In order to use the blower and valve assembly for example as shown in Fig. 2 as a resuscitator the entire assembly is unclamped from the respirator **1** and a resuscitator manifold generally indicated by the reference numeral **200** is clamped to the back plate **26***a* of the housing **26** with the sealing gasket **90** interposed as seen in Fig. 8. As seen in this figure the manifold housing is in the form of a rectangular box **201** which is open on its rear side and provided at each end with a rod **202** threaded to receive clamping wing nuts **203** so that the manifold assembly may be clamped to the valve and blower assembly with the chamber **204** in the manifold

communicating with the ports **86** and **96** Fig. 4, of the valve mechanism. The chamber **204** replaces the respirator.

The manifold housing **201** is provided on its upper side with three outlet conduits **205**, **206** and **207** to each of which an oxygen mask inlet tube may be connected and the ones not in use may be plugged with a rubber stopper.

On its front face the manifold housing **201** is drilled with a plurality of ports arranged in a rectangular pattern in two sets one indicated by reference numeral **208** and the other by the numeral **210**. A flap valve **212** is positioned in the chamber **204** and adapted to cooperate with the ports **208** to admit air from the atmosphere to the chamber **204**. An adjusting screw **214** limits the amount of opening of the valve **212** and hence controls the sub-atmospheric pressure in the chamber **204**. A similar flap valve **215** is mounted on the front of the manifold housing **201** to cooperate with the ports **210** to control the discharge of air under pressure from the chamber **204** and thus limit the positive pressure in the chamber. The extent of movement of the valve **215** is determined by an adjusting screw **216**.

The manifold **201** is further provided with a dual range gauge **220** (Fig. 11) for measuring the magnitude of the positive and negative pressures in the chamber **204** for the purpose of adjusting the valves **212** and **215**.

When an oxygen mask **225** Fig. 10 is connected by means of its inlet tube **228** to one of the outlet conduits such as **205** the resuscitator can be placed into operation. The valve and blower assembly is energized from a 24 volt direct current source and the cycling rate of the valve mechanism adjusted by operation of the speed control rheostat knob **151** (Fig. 2) positive and negative pressure cycles will be produced in the resuscitator chamber **204** in exactly the same manner as previously described with respect to the operation of the respirator.

When the manifold chamber **204** is filled with air under perssure this pressure is transferred to the mask **225** and inflates the lungs of the patient wearing the mask. When the cycle changes to produce a negative pressure in the manifold chamber **204** the reduction is transferred to the mask and air is exhaled from the patient's lungs. The maximum pressures during inhalation and exhalation can be adjusted to suit the medical needs of the patient and may range from 35 centimeters to water positive to 20 centimeters of water negative pressure.

To prevent rebreathing some of the exhaled air a vent tube **230** is provided on the mask, see Fig. 10 which allows fresh air to enter the mask **225** and inlet tube **228** during the exhalation part of the cycle.

We claim:

1. Respirator apparatus comprising a respirator chamber adapted to enclose at least the thoracic regions of the human body, means providing a restricted passage for the flow of air into and out of said chamber, an air pump having an inlet and an outlet, power means for continuously driving the pump, first valve means operative to connect the inlet of the pump to the respirator chamber to produce a flow therethrough from said restricted passage and a subatmospheric pressure therein, a second valve means operative to simultaneously connect the outlet of the pump to atmosphere, said first and second valve means being alternately operable respectively to connect the inlet of the pump to atmosphere and the outlet of the pump to the respirator chamber to cause a flow therethrough at superatmospheric pressure, a cam shaft, a pair of cams mounted on said shaft each operable to cyclically actuate a respective one of said valve means and an adjustable speed motor for continuously driving said cam shaft.

2. Respirator apparatus comprising a respirator chamber adapted to enclose at least the thoracic regions of the human body, means providing a restricted passage for the flow of air into and out of the chamber, an air pump having an inlet and an outlet, power means for continuously driving the pump, a pair of alternately operable two position valves, each valve having a flow connection to the respirator chamber and to the ambient atmosphere, the first of said valves having a further flow connection to the inlet side of said pump and the second of said valves having a further flow connection to the outlet side of the pump, the first of said valves in one position connecting the respirator chamber to the inlet of the pump and connecting in its other position the inlet of the pump to the atmosphere, the second valve in one position connecting the respirator chamber to the outlet of the pump and in the second position connecting the outlet of the pump to the atmosphere, cam means for moving said valves alternately, one valve being in its first position when the other valve is in its second position and vice versa, power means for continuously driving said cam means and means for adjusting the cyclic rate of operation of said cam means.

3. Respirator apparatus comprising a respirator chamber adapted to at least enclose the thoracic regions of the human body, means providing an adjustable restricted passage for the flow of air into and out of said chamber, an air pump having an inlet and an outlet, a first passage means connected to the pump inlet, a second passage means connected to the pump outlet, a pair of lateral conduits operatively associated with said first passage means, one of the conduits being connected to the atmosphere and the other conduit being connected to the respirator chamber, a valve movable alternately to open one of said conduits and to close the other and vice versa, a pair of lateral conduits operatively associated with said second passage means one of the conduits being connected to the atmosphere and the other conduit being connected to the respirator chamber, a valve movable alternately to open one of said conduits and to close the other and vice versa, a valve rod yieldingly coupled to one of said valves, a second valve rod yieldingly connected to the other of said valves, a cam having a predetermined shape for actuating one of said valve rods, a second cam having a predetermined shape different than the first named cam for actuating the other of said valve rods and power actuated driving means for continuously driving said cams with a fixed phase relation to each other, the yielding connection between each of said valve rods and its associated valve permitting the phase relation of the valves to be controlled by the cam shapes irrespective of the fixed phase relation of the cams to each other.

4. For use with respiratory apparatus of the character described a pump and valve assembly comprising a housing, a pump in said housing and having an inlet and an outlet, a partition in said housing dividing the housing into two chambers one an inlet chamber connected to the pump inlet and the other a discharge chamber connected to the pump outlet, a valve housing mounted on said first named housing and having a first valve chamber connected to the said inlet chamber and a second valve chamber connected to the said discharge chamber, a separate conduit in each of said valve chambers adapted to be connected to external respiratory apparatus to produce pressure changes therein, a separate conduit in each of said valve chambers connected to the atmosphere, a double acting valve in each valve chamber adapted to cooperate with the conduits therein to alternately connect the valve chamber to the utilizing apparatus and to the atmosphere, and actuating means connected to each of said valves to continuously actuate the valves in opposite phase relation said actuating means being yieldingly connected to each of the valves whereby the actuating means may overtravel relative to the valves in each direction of movement thereof.

5. The structure as claimed in claim 4, in which the actuating means for the valves comprise valve rods yieldingly connected to the valves, cam followers on each valve rod, a rotatable cam associated with each cam follower, a cam shaft for driving said cams in a fixed

relation to each other, adjustable speed power means for driving said cam shaft, each of said cams having a predetermined contour characteristic of the desired rate of movement and dwell of each valve, said cams positively moving the valves in one direction and spring means associated with each valve actuating rod for moving the rod and associated valve in the opposite direction of movement.

6. In a resuscitator system, a face mask adapted to be worn by the patient, a manifold chamber connected to said face mask, an air pump having an inlet and an outlet, power means for continuously driving said air pump, a first valve adapted when moved in one position to connect the inlet of the pump to atmosphere and in a second position to connect the inlet of the pump to the manifold chamber, a second valve adapted when in one position to connect the pump outlet to the atmosphere and in a second position to connect the pump outlet to the manifold chamber, means for continuously and cylically actuating said valves in opposite directions of movement to cyclically and alternately connect said manifold chamber to the pump inlet to create a negative pressure in the manifold chamber then to the pump outlet to create a positive pressure in the manifold chamber and means for adjustably regulating the maximum negative and positive pressures in the manifold chamber.

7. The structure as claimed in claim 6, in which the means for actuating the valves include a pair of continuously rotating cams each cam associated with a respective valve, and the cams being respectively shaped to give a predetermined rise, decay and duration of the positive and negative pressure portions of the cycle.

8. The structure as claimed in claim 6, in which the face mask is provided with an air bleed opening adapted to flush the mask and connecting conduit with fresh air during the exhalation portion of the resuscitator cycle to reduce rebreathing exhaled air.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 20,226	Drinker et al.	Jan. 5, 1937
1,087,942	Hammond	Feb. 24, 1914
1,136,517	Drager	Apr. 20, 1915
2,427,665	Emerson	Sept. 23, 1947
2,456,724	Mullikin	Dec. 21, 1948