Feb. 4, 1964 T. C. HUXLEY III 3,120,228

RESPIRATOR APPARATUS

Filed Nov. 7, 1960 3 Sheets-Sheet 1

Fig. 5.

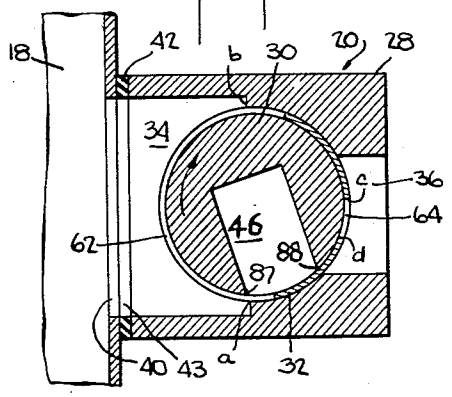

Fig. 1.

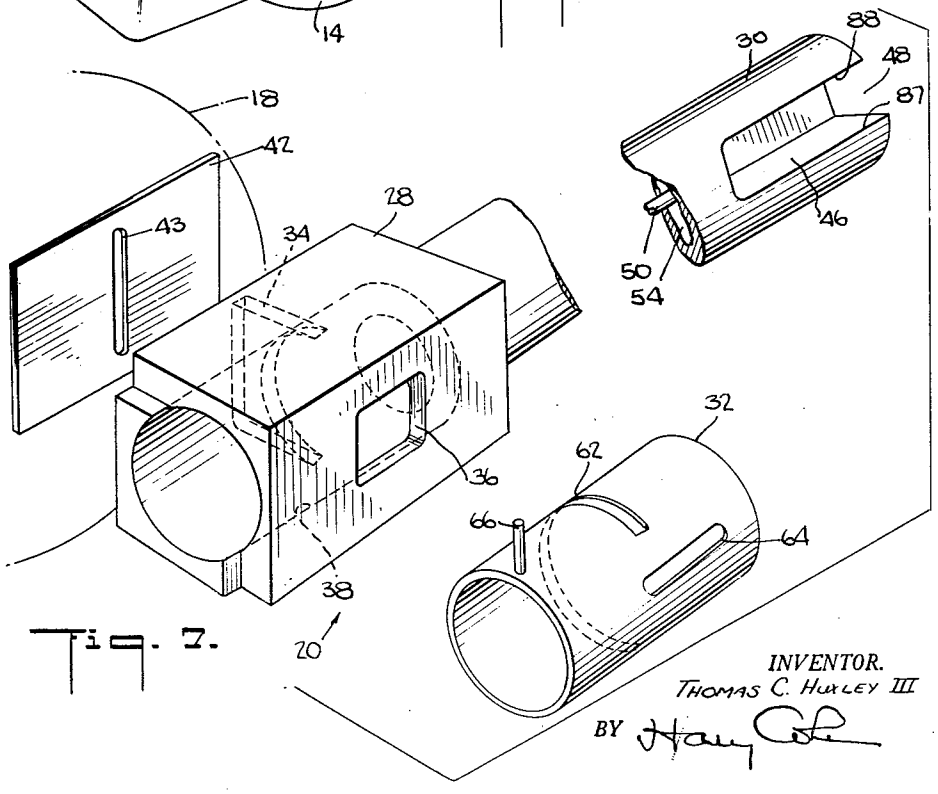

Fig. 7.

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RESPIRATOR APPARATUS

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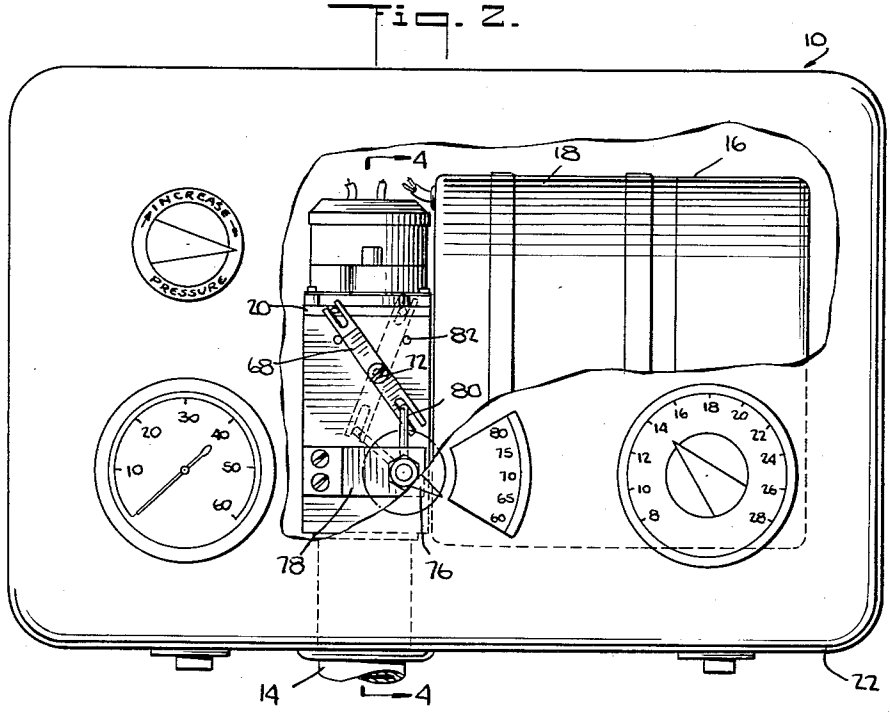
Fig. 2.



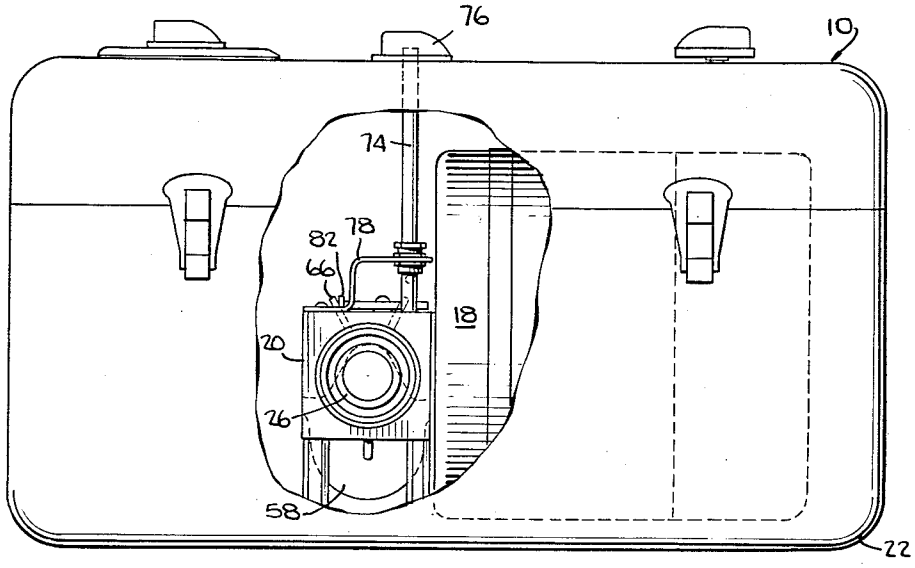


Fig. 3.

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RESPIRATOR APPARATUS

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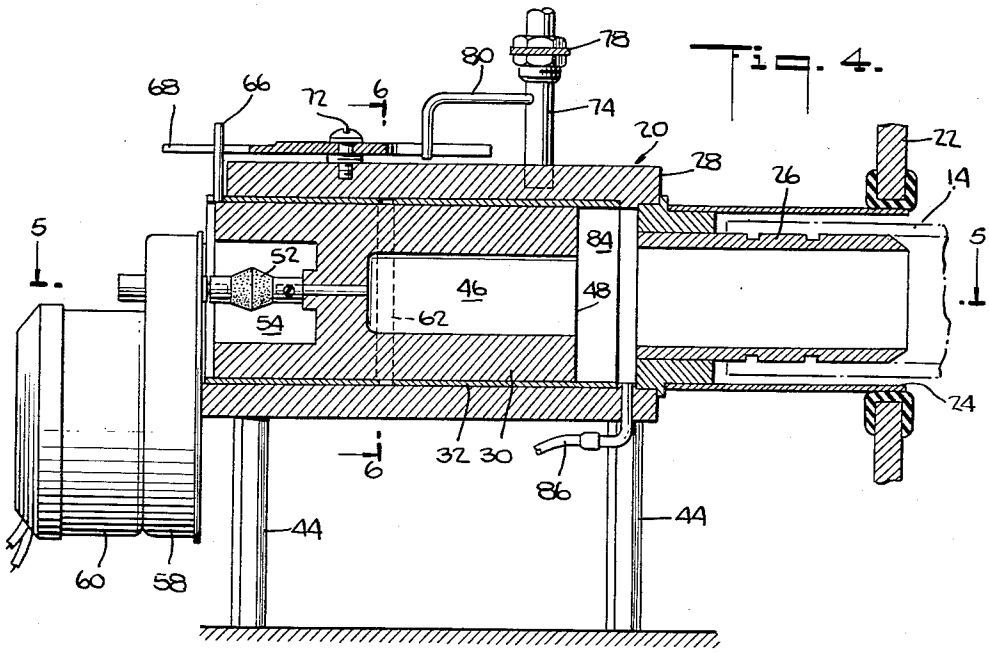
Fig. 4.



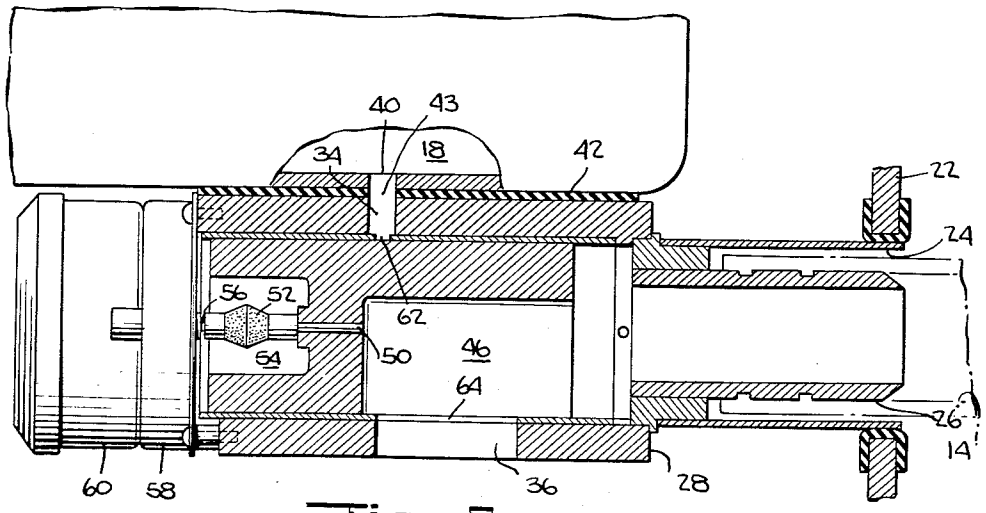


Fig. 5.

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United States Patent Office

3,120,228

Patented Feb. 4, 1964

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3,120,228

RESPIRATOR APPARATUS

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Filed Nov. 7, 1960, Ser. No. 67,606
5 Claims. (Cl. 128—30)

The present invention relates to pumping apparatus for artificial respirators.

The primary object of the invention is the provision of a rotary respirator pump with means operable in conjunction with respirator apparatus for inducing breathing in a manner similar to normal breathing in respect to the rate of inhalation in comparison with the rate of exhalation in a breathing cycle. Pumping apparatus for accomplishing such differential inhalation and exhalation has heretofore been provided, as shown for example, in the U.S. Patent No. 2,845,062 issued July 29, 1958, upon an application filed by me and Nelson G. Kling as joint inventors. According to said patent, a reciprocating-piston pump is provided and the piston is moved more rapidly in one direction than in the opposite direction for obtaining the desired above indicated result. Pursuant to the present invention, it is possible to employ a constant speed rotary pump and yet provide for said differential breathing rates in a breathing cycle, with a light weight and inexpensive pumping apparatus and improved valve means.

Another object is to provide a light weight, portable respirator apparatus of the above indicated type with means for varying the ratio of the period of inhalation of the breathing cycle to the period of exhalation of the breathing cycle in accordance with the needs of the person.

A further object is to provide valve means especially well adapted to accomplish the aforementioned objects.

The above and other objects, features and advantages of the present invention will be more fully understood from the following description considered in connection with the accompanying illustrative drawings.

In the drawings:

FIG. 1 is a perspective view illustrating the respirator pumping apparatus of the present invention in operative association with an artificial respirator device;

FIG. 2 is a top plan view of the respirator pumping apparatus with portions cut away for purposes of illustration;

FIG. 3 is a front elevational view of the respirator pumping apparatus with portions cut away for illustrative purposes;

FIG. 4 is a vertical sectional view, on an enlarged scale, taken on line 4—4 of FIG. 2;

FIG. 5 is a horizontal sectional view taken on line 5—5 of FIG. 4;

FIG. 6 is a cross section taken on line 6—6 of FIG. 4 with part of the apparatus in a position which is different from its position in FIG. 4; and

FIG. 7 is an exploded perspective view of some of the parts of the apparatus of the present invention, illustrating said parts in a disassembled condition.

Referring now to the drawings in detail, and particularly to FIG. 1 thereof, there is shown a respirator pumping apparatus 10, pursuant to the present invention, which is operatively connected to an artificial respirator device 12, herein illustrated as an abdominal belt of the type

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shown in U.S. Patent No. 2,762,366, in body encircling relation on the patient P for effecting artificial respiration. The pumping apparatus is operative to rhythmically vary the air pressure applied to the inflatable bladder 13 of the abdominal belt, through connecting conduit 14, to effect respiration.

In accordance with the invention, the respirator pumping apparatus 10 comprises a relatively light and inexpensive rotary blower 16 for supplying air to a storage chamber 18 which is mounted next to the blower in communication therewith, the blower and chamber being illustrated herein as a connected unit. A valve 20 is mounted adjacent chamber 18 and in fluid communication therewith for controlling the flow of air from the chamber to the respirator device 12 and for this purpose the housing 22 of apparatus 10 is provided with an opening 24 through which one end of conduit 14 extends for securing said end to a tube 26 which is in fluid flow communication with the valve. As will be more fully understood hereinafter, valve 20 is operated to control the flow of pressure fluid to and from the respirator device 12 so that the period of inhalation of the breathing cycle is more rapid than the period of exhalation of the breathing cycle. In addition, valve 20 includes means for varying the ratio of the period of inhalation to the period of exhalation.

The valve comprises the stationary housing member 28, the rotary member 30 disposed within member 28 and mounted for rotational movement therein, and movable sleeve 32 mounted on the rotary member in sliding relation therewith and disposed between the rotary member and the stationary housing member. The housing member is generally of rectangular configuration and includes an inlet opening or passage 34 and an outlet opening or passage 36, each of said openings being in communication with the axially extending bore 38 which contains the rotary member 30 and the sleeve 32. The side of the housing member 28 provided with inlet opening 34 is mounted against the side of chamber 18 so that outlet opening 40 therein is in alignment with inlet opening 34. A gasket 42 having a passage 43 is disposed between chamber 18 and the side of the valve housing 28 to ensure a fluid type connection between openings 40 and 34. Outlet opening 36 is in communication with the atmosphere in the housing 22. The housing member is mounted on vertical spaced members 44 (FIG. 4) which support the valve 20 in correct position in the housing 22 of apparatus 10.

The rotary member 30 is of cylindrical shape and has a passage 46 which extends axially of the member and forms opening 48 at one end of the member. Opening 48 is in communication with tube 26 in all positions of the rotary member 30. Passage 46 also extends transversely to the cylindrical surface of member 30 and is in confronting relation with the internal wall of sleeve 32. A shaft 50 is secured to the rotary member 30 and a coupling 52, provided in the recess 54 at the other end of the rotary member, connects shaft 50 to the drive shaft 56 of a reduction gear 58. The reduction gear is driven by the electric motor 60 and in this manner rotary member 30 is rotated within the stationary housing 28 of the valve.

Sleeve 32 has an inlet opening 62 which extends circumferentially of the sleeve and an outlet opening 64 which is opposite the inlet opening and extends axially of the sleeve. Inlet opening 62 is adapted to be in confronting relation with inlet opening 34 of housing member 28 in

all positions of the sleeve and outlet opening **64** is adapted to be in confronting relation with outlet **36** of the housing member. Means are provided for rotating sleeve **32** with respect to housing member **28** to vary the relative positions of openings **36** and **64** and in this manner vary the ratio of the period of inhalation to the period of exhalation of a breathing cycle. More particularly, sleeve **32** is provided with a pin **66** which extends upwardly past the valve housing **28** and is engaged by one end of the forked actuating member **68**. The actuating member is mounted on a pivot **72** which is screwed into the housing member of the valve to permit pivotal movement of member **68** for rotating sleeve **32** into various positions. A vertical rod **74** extends upwardly from the valve housing member **28** through the cover of the housing **22** of the apparatus **10** and the upper end of the rod is provided with an actuating knob **76**. The lower end of rod **74** is mounted for pivotal movement in the valve housing member and the rod is supported in its vertical position by bracket **78**. The lower part of the rod is provided with the hook-like member **80** which extends into the slot provided by the other forked end of actuating member **68**. By rotating knob **76**, sleeve **32** is caused to rotate on rotary member **30** into the position desired to obtain the correct ratio of the period of inhalation to the period of exhalation of a breathing cycle in accordance with the needs of the person. The housing member **28** is provided with stops **82** (FIG. 2) which limit the movement of sleeve **32** so that sleeve opening **64** does not move past the upper or lower edges which define opening **36** in the housing **28**.

The operation of the valve **20** will now be described with particular reference to FIG. 6. As therein shown, rotary member **30** is being rotated in a clockwise direction by the motor and reduction gear **60**, **58**. As shown, no pressure fluid is being transmitted to respirator device **12** because passage **46** of rotary member **30** is not in communication with passage **34** of housing member **28** but is at the position where communication just begins, the leading edge **87** of passage **46** being at position *a* of the valve housing member **28**. Also, since passage **46** of the rotary member is not in communication with opening **64** of sleeve **32**, no pressure fluid is being transmitted from the device **12** to the atmosphere through passage **46**, opening **64** and opening **36**, respectively, it being understood that passage **46** is always in communication with the respirator device via conduit **14**, tube **26**, and the space **84** (FIGS. 4 and 5) which is between the end opening **48** of passage **46** and the inner end of tube **26**. As seen in FIGS. 4 and 5, the bottom of the space **84** is provided with a tube **86** which is connected to a pressure gage for indicating the pressure in the respirator device. Although there is some communication between passage **46** and passage **34** via the portion of opening **62** of the sleeve **32** which a portion of passage **46** is in confronting relation with, the relatively small thickness of the sleeve does not permit any appreciable amount of pressure fluid to be transmitted to the respirator device.

As passage **46** moves past position *a*, communication is established between chamber **18** and passage **46** so that pressure fluid flows from the chamber through opening **40** into opening **34** of the valve housing **28** and through opening **62** of the sleeve **32** into passage **46** through the portions of said passage which has moved past position *a*. From passage **46** the pressure fluid flows through tube **26** and conduit **14** into the respirator device **12** to inflate the device and effect the beginning of the exhalation period of a breathing cycle. Exhalation continues until the trailing edge **88** of the passage **46** of the rotary member **30** reaches position *b* of the valve housing member wherein communication between chamber **18** and the respirator device is cut-off. At this position the exhalation period ends and the respirator device is not in communication with inlet opening **34** or outlet opening **36** of the housing member so that no inhalation or exhalation takes place.

The period of inhalation begins when the leading edge **87** of the passage **46** of the rotary member moves into position *c* which is at one edge of outlet opening **64** of the sleeve **32**. At this position, the inflated respirator device **12** begins to deflate and fluid pressure flows from the device through conduit **14** and tube **26** to the valve and passes into the atmosphere through passage **46** of the rotary member, outlet opening **64** of sleeve **32** and opening **36** of the valve housing member **28**, it being understood, as previously indicated, that opening **36** is exposed to the atmosphere. The deflation of respirator device **12** and the concomitant inhalation of the person continues until trailing edge **88** of the rotary member reaches the position *d* where communication between outlet opening **36** and passage **46** is cut-off. It will be understood that the parts of the valve **20** are so dimensioned that when edge **88** of the rotary member is at position *d*, edge **87** of the rotary member has not reached position *a*. In this manner the respirator device **12** is never in communication with chamber **18** and the atmosphere at the same time. The exhalation period commences, as previously indicated, when edge **87** of the rotary member moves past position *a*.

It will be noted that passage **46** in rotary member **30** permits fluid pressure to enter the bladder **13** relatively slowly at the start of the exhalation period, and also permits fluid pressure to flow from the bladder relatively slowly at the start of the inhalation period, whereby no sudden pressures or shock loads are applied to the person during transition from inhalation to exhalation or vice versa.

From the foregoing it will be apparent that the amount of rotation of rotary member **30** and consequently the period of time in which passage **46** is in communication with chamber **18** is substantially greater than the amount of rotation of the rotary member and consequently the period of time in which passage **46** is in communication with the atmosphere. Accordingly, the period of exhalation is substantially greater than the period of inhalation in a breathing cycle and this is in accordance with the normal phenomenon of breathing. In order to vary the ratio of the period of inhalation to the period of exhalation of a breathing cycle, sleeve **32** may be rotated in the manner previously described to vary the position of the opening **64** of the sleeve with respect to the opening **36** of the valve housing member. Such variation of the period of inhalation to the period of exhalation of the breathing cycle may be made to accommodate the various breathing requirements of different persons.

While I have shown and described the preferred embodiment of my invention, it will be understood that the invention may be embodied otherwise than as herein specifically illustrated or described and that certain changes in the form and arrangement of parts and in the specific manner of practicing the invention may be made without departing from the underlying ideas or principles of this invention within the scope of the appended claims.

I claim:

1. In respirator pumping apparatus comprising a rotary blower adapted to be connected to a respirator device in fluid flow communication therewith for rhythmically varying fluid pressure therein for inducing breathing, said respirator device being adapted to engage a portion of the person's body for effecting breathing and said apparatus comprising a blower for supplying pressure fluid to said device, the combination with said blower of rotary valve means for controlling the flow of pressure fluid to and from said device to provide a period of inhalation of the breathing cycle which is more rapid than the period of exhalation of the breathing cycle, said rotary valve means comprising a stationary valve member and a rotary valve member mounted for rotation in said stationary member, means for driving said rotary valve member, said rotary member having a passage in fluid flow communication with said device and said stationary member having a passage in fluid flow communication with said blower, said

stationary member having another passage in fluid flow communication with the atmosphere, each of said passages in said stationary member being in communication with said passage in said rotary member at predetermined positions, respectively, of said rotary member, whereby in one position of said rotary member said blower is in communication with said device to supply pressure fluid thereto and in another position of said rotary member said device is in communication with the atmosphere for transmitting pressure fluid thereto, and an adjustable valve member positioned between said stationary valve member and said rotary member and having fluid passages disposed relative to said first mentioned fluid passages for varying the ratio of the period of inhalation to the period of exhalation of the breathing cycle.

2. In respirator pumping apparatus comprising a rotary blower adapted to be connected to a respirator device in fluid flow communication therewith for rhythmically varying fluid pressure therein for inducing breathing, said respirator device being adapted to engage a portion of the person's body for effecting breathing and said apparatus comprising a rotary blower for supplying pressure fluid to said device, the combination with said blower of rotary valve means for controlling the flow of pressure fluid to and from said device to provide a period of inhalation of the breathing cycle which is more rapid than the period of exhalation of the breathing cycle, said rotary valve means comprising a stationary member having an inlet opening and an outlet opening, a rotary member mounted for rotation in said stationary member and having a passage therein in communication with said respirator device, means for rotating said rotary member, said passage being in communication with said inlet opening in one position of said rotary member and in communication with said outlet opening in another position of said rotary member, said inlet opening being longer in the direction of rotation of said rotary member than said outlet opening, whereby said passage is in communication with said inlet opening for a longer period of time than said passage is in communication with said outlet opening and in said one position of said rotary member said blower is in communication with said device to supply pressure fluid thereto and in said other position of said rotary device said device is operative to transmit pressure fluid therefrom, and an adjustable valve member positioned between said stationary valve member and said rotary member and having fluid passages disposed relative to said first mentioned fluid passages for varying the ratio of the period of inhalation to the period of exhalation of the breathing cycle.

3. In respirator pumping apparatus comprising a rotary blower adapted to be connected to a respirator device in fluid flow communication therewith for rhythmically varying fluid pressure therein for inducing breathing, said respirator device being adapted to engage a portion of the person's body for effecting breathing and said apparatus comprising a rotary blower for supplying pressure fluid to said device, the combination with said blower of rotary valve means for controlling the flow of pressure fluid to and from said device to provide a period of inhalation of the breathing cycle which is more rapid than the period of exhalation of the breathing cycle, said rotary valve means comprising a stationary member having an inlet opening and an outlet opening, a rotary member mounted for rotation in said stationary member and having a passage therein in communication with said respirator device, means for driving said rotary member, said passage being in communication with said inlet opening in one position of said rotary member and in communication with said outlet opening in another position of said rotary member, said inlet opening being longer in the direction of rotation of said rotary member than said outlet opening, whereby said passage is in communication with said inlet opening for a longer period of time than said passage is in communication with said outlet opening and in said one position of said rotary member said blower is in communication with said device to supply pressure fluid thereto and in said other position of said rotary device said device is operative to transmit pressure fluid therefrom, said rotary valve means including means mounted on said rotary member for varying the position at which said passage of said rotary member is in communication with one of said openings of said stationary member and thereby varying the ratio of the period of inhalation to the period of exhalation.

4. In respirator apparatus, comprising a respirator device adapted to engage a portion of the person's body for effecting breathing, and pumping apparatus for rhythmically varying fluid pressure in said device, and means connecting said pumping apparatus and respirator device in fluid flow communication for permitting the flow of pressure fluid therebetween, said pumping apparatus comprising a rotary blower for supplying pressure fluid to said device, the combination with said blower of rotary valve means for controlling the flow of pressure fluid to and from said device to provide a period of inhalation of the breathing cycle which is more rapid than the period of exhalation of the breathing cycle, said rotary valve means comprising a stationary member having an inlet opening and an outlet opening, a rotary member mounted for rotation in said stationary member and having a passage therein in communication with said respirator device, means for driving said rotary member, said passage being in communication with said inlet opening in one position of said rotary member and in communication with said outlet opening in another position of said rotary member, said inlet opening being longer in the direction of rotation of said rotary member than said outlet opening, whereby said passage is in communication with said inlet opening for a longer period of time than said passage is in communication with said outlet opening and in said one position of said rotary member sai dblower is in communication with said device to supply pressure fluid thereto and in said other position of said rotary device said device is operative to transmit pressure fluid therefrom, and an adjustable valve member positioned between said stationary valve member and said rotary member and having fluid passages disposed relative to said first mentioned fluid passages for varying the ratio of the period of inhalation to the period of exhalation of the breathing cycle.

5. In respirator apparatus, comprising a respirator device adapted to engage a portion of the person's body for effecting breathing, and pumping apparatus for rhythmically varying fluid pressure in said device, and means connecting said pumping apparatus and respirator device in fluid flow communication for permitting the flow of pressure fluid therebetween, said pumping apparatus comprising a rotary blower for supplying pressure fluid to said device, the combination with said blower of rotary valve means for controlling the flow of pressure fluid to and from said device to provide a period of inhalation of the breathing cycle which is more rapid than the period of exhalation of the breathing cycle said rotary valve means comprising a stationary member having an inlet opening and an outlet opening, a rotary member mounted for rotation in said stationary member and having a passage therein in communication with said respirator device, means for driving said rotary member, said passage being in communication with said inlet opening in one position of said rotary member and in communication with said outlet opening in another position of said rotary member, said inlet opening being longer in the direction of rotation of said rotary member than said outlet opening, whereby said passage is in communication with said inlet opening for a longer period of time than said passage is in communication with said outlet opening and in said one position of said rotary member said blower is in communication with said device to supply pressure

fluid thereto and in said other position of said rotary device said device is operative to transmit pressure fluid therefrom, said rotary valve means including means mounted on said rotary member for varying the position at which said passage of said rotary member is in communication with one of said openings of said stationary member for varying the ratio of the period of inhalation to the period of exhalation.

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