March 3, 1959 E. A. J. TUNNICLIFFE ET AL 2,875,946

MECHANICAL BREATHING APPARATUS

Filed Sept. 13, 1956

4 Sheets-Sheet 1

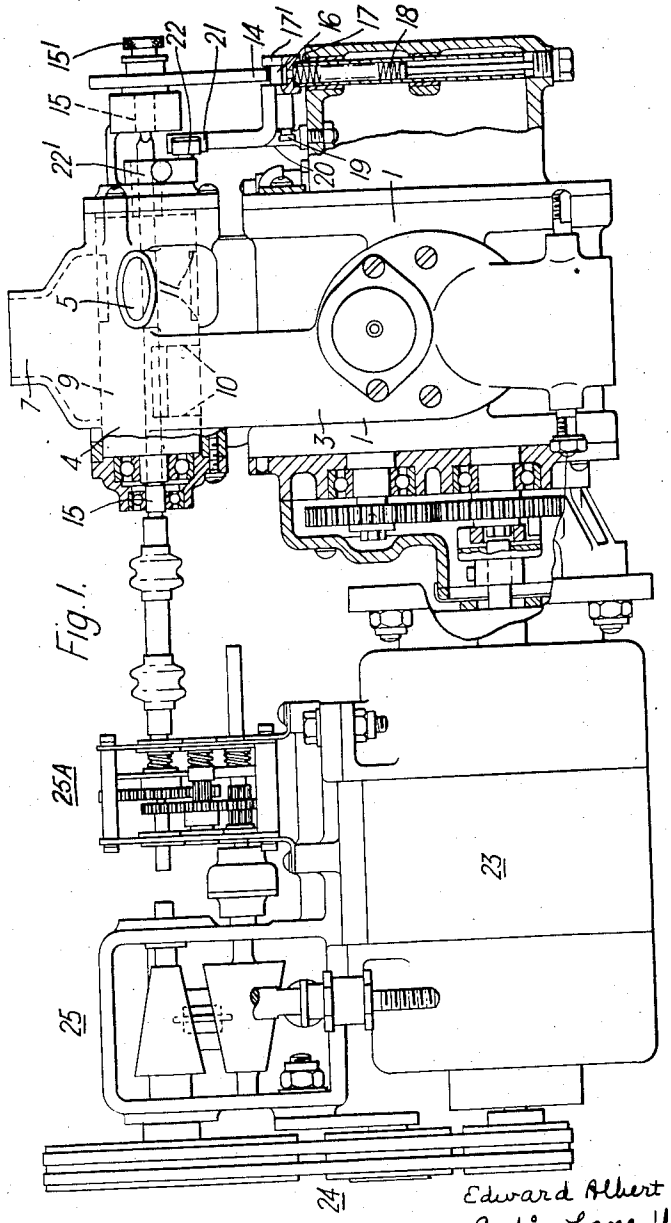

Fig. 1.

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Fig. 2.

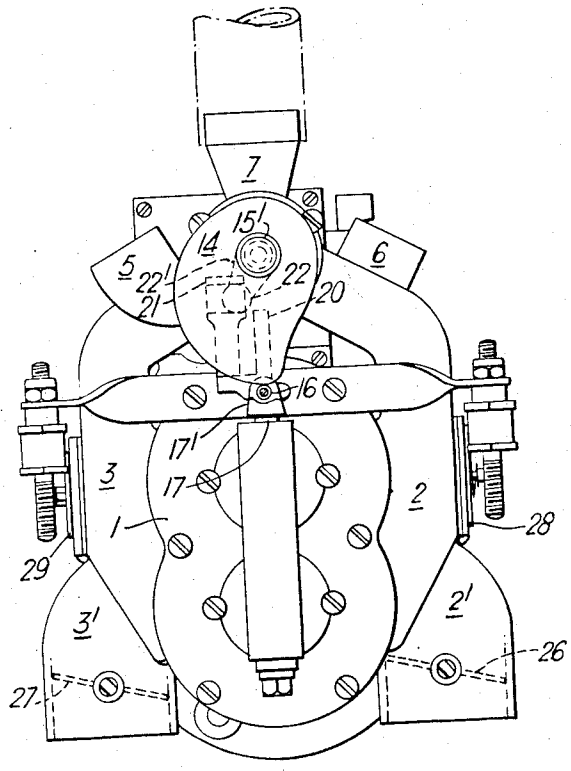

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Fig. 3.

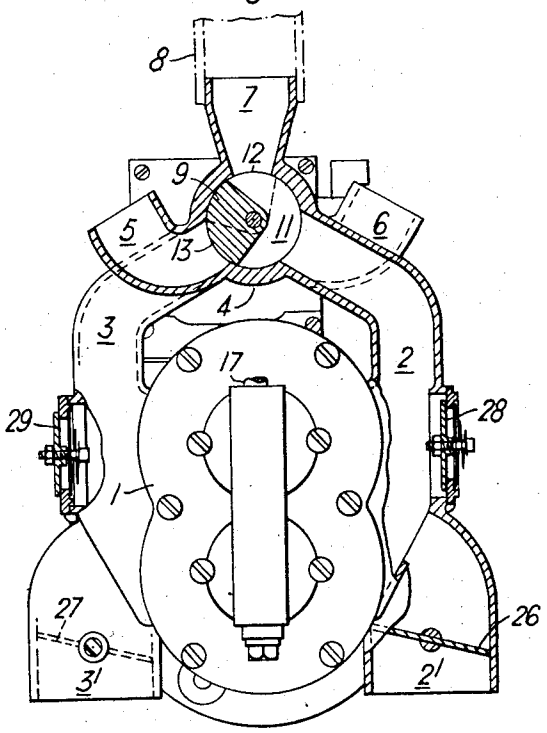
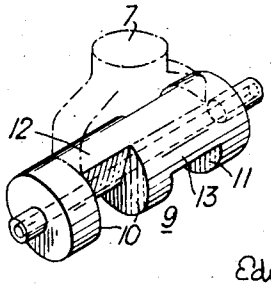


Fig. 4.



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MECHANICAL BREATHING APPARATUS

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Fig.5.

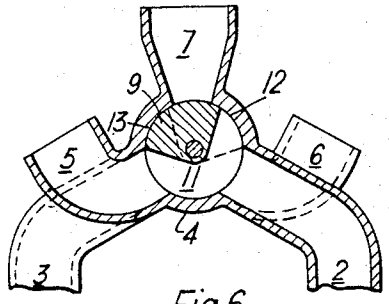


Fig.6.

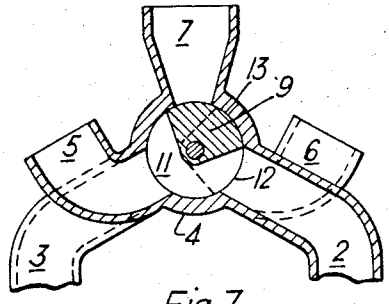
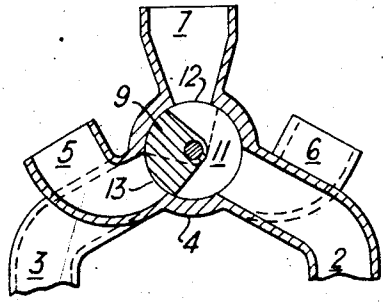


Fig.7.



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MECHANICAL BREATHING APPARATUS

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Application September 13, 1956, Serial No. 609,763

Claims priority, application Great Britain September 13, 1955

5 Claims. (Cl. 230—42)

This invention is concerned with mechanical breathing apparatus for use in maintaining the breathing action of a human being by the application of a pulsating pressure to some part at least of the thoracic area and/or abdominal area.

It is now usual to set up the pulsating pressure by the application of a pulsating air pressure to the apparauts: in the use of such apparatus, it is essential that the pulsating air pressure shall be capable of wide regulation to suit the different cases and conidtions which arise: this invention is more particularly concerned with mechanism to establish the pulsating pressure air supply and it has for its object to proivde a mechanism which shall be capable of a wide range of adjustment to enable the different requirements to be met.

In carrying out this invention the mechanism comprises a positive displacement air pump, a discharge duct for connection to a mechanical breathing apparatus, valve means to open and close the discharge duct to the intake and output side of the pump, a variable speed drive to operate the valve means in constantly recurring cycles and adjustable pressure-control valves controlling the connection of the intake and output sides of the pump to atmosphere.

In view of the use for which such mechanism is intended, it is desirable that the pump shall be of a type which does not require lubrication of its air contacting surfaces. For this reason the pump employed is preferably of the rotating lobe type in which the lobes are driven in synchronism with a constant small clearance between their cooperating air displacement surfaces: such a type is exemplified by the well known "Rootes Blower" type.

The valves which control the connection of the discharge duct respectively to the intake and output sides of the pump (these valves being referred to as the phasing valves) control the setting up of the impulses in each cycle as they alternately connect the duct to the low pressure (suction) side of the pump and the high pressure (delivery) side: the timing of operation of the two valves determines the relative timing of the high and low pressure phases in each cycle and the perodicity of the cycles will depend on the speed at which the valves are operated: the maximum and minimum pressure values in the high and low pressure phases will depend on the setting of the adjustable pressure-control valves. Such a machanism therefore enables variation to be made within a very wide range and so enables the breathing apparatus which is associated with the mechanism to deal adequately with the various requirements.

When the pump output is diverted from the discharge duct, it can pass direct to atmosphere or it can be taken to the intake side of the pump so as to enable the heat of compression of the air to be utilized in raising the temperature of the air passing to the intake side.

The operating mechanism for the phasing valves can be formed by a rotatable cam which is driven continuously at a variable rate: the form of the cam when taken in

conjunction with the shaping of the control ports of the valves themselves will enable the rate of change of the two phases to be chosen to meet the conditions imposed in the use of the mechanism.

The invention is illustrated by way of example in the accompanying drawings in which Figure 1 is a sectional side elevation of a unit comprising the pump, the various valves and a variable speed driving mechanism, and Figure 2 is an end elevation of the unit. Figure 3 is a sectional view showing the arrangement of certain flow passages, Figure 4 is a perspective view of the phasing valve, and Figures 5, 6 and 7 are diagrammatic views showing the phasing valve in three different positions.

Referring to the drawings, **1** indicates the casing of a Rootes blower having an intake or suction duct **2** and a pressure duct **3**: such a form of pump is well known and further description of it is believed to be unnecessary, it being sufficient to say that the blower comprises two lobed rotors which are driven in synchronism and which serve to draw-in air through the duct **2** (which therefore is at negative pressure) and deliver the air to the duct **3** (which is therefore at a positive pressure).

The ducts **2** and **3** pass up about the opposite sides of the pump casing **1** to a valve housing **4**: from this housing extend ducts **5**, **6** which are open at their ends to the atmosphere, the duct **5** aligning with the suction duct **2** and the duct **6** aligning with the pressure duct **3**. From this housing **4** also extends a discharge duct **7** which is arranged to receive one end of a flexible pipe **8** the other end of which is arranged to be connected to the mechanical breathing apparatus which can be of any known kind.

The various ducts **2**, **3**, **5**, **6** and **7** open to the cylindrical bore of the housing **4** and within this bore is a phasing valve cock or plug **9**. This valve is cut away as is shown in Figure 4 to provide two transfer recesses **10**, **11** which are spaced apart lengthwise of the plug **9**. The cross sectional form of the transfer recesses is identical but the recesses are angularly displaced from one another about the axis of the plug, the recesses leaving blanking lands **12**, **13** which are also angularly displaced. The land **12** controls the connection to the pressure duct **3** while the land **13** controls the connection to the suction duct **2**.

The plug **9** is oscillated so as to connect the duct **7** alternately to the suction duct **2** and the pressure duct **3** so as to set up the required pulsating air pressure in the duct **7**. Moreover, the arrangement is such that the pump is always in operation and in the pressure phase of the pulsating air pressure draws air in from the atmosphere and delivers the air to the duct **7** and in the negative pressure phase draws air from the duct **7** and discharges that air to atmosphere.

The operation will be more clearly understood from Figures 5–7: in Figure 5, the lands **12** and **13** both shut the duct **7** so that the duct is isolated from the suction and pressure ducts **2**, **3**, the recess **11** connecting the suction duct **2** with the open duct **5** to enable the pump to draw-in air and the recess **10** connecting the pressure duct **3** with the open duct **6** so that the air is discharged to atmosphere. The position shown in Figure 5 is an intermediate position which the plug **9** passes through in moving from one extreme position to another.

In Figure 6 is shown the position occupied by the plug after it has passed through the intermediate position of Figure 5 to the position to set up a positive pressure in the duct **7**: in this position the suction duct **2** is connected by the recess **11** to the open duct **5** and the corresponding land **13** isolates the duct **7** from that connection: in addition, the recess **10** connects the pressure duct **3** with the duct **7** and the corresponding land **12** closes the duct **6**. Thus the pump draws in air from

the atmosphere and delivers that air under pressure to the duct 7.

In Figure 7 is shown the position occupied by the plug after it has passed from the position of Figure 6 through the intermediate position of Figure 5 to the position to set up a negative pressure in the duct 7: in this position the suction duct 2 is connected to the duct 7 via the recess 11, and this connection is isolated from the open duct 5 by the corresponding land 13: the recess 10 connects the pressure duct 3 to the open duct 6 and the corresponding land 12 closes the duct 7 from that connection. Thus the pump draws air from the duct 7 and discharges that air to atmosphere.

It will be clear that the land 12 and the associated recess 10 constitute one phasing valve which controls the pressure duct 3 and the land 13 and associated recess 11 constitute another phasing valve controlling the suction duct 2: the valves could therefore be formed as separate entities but it is preferred as shown to incorporate them in the one plug.

The plug 9 is arranged to be oscillated from one extreme position to the other by a cam 14 which is detachably clamped on a spindle 15 by a nut 15', the cock 9 being supported for angular movement on that spindle: the cam is engaged by a follower 16 on a bracket 17' carried by a slide 17 which is urged upwardly by a spring 18, the bracket having guide rollers 19 cooperating with a fixed guide rod 20 which holds the bracket 17' from turning. The bracket is formed at its upper end with a jaw head 21 which cooperates with an anti-friction bearing on a stud 22 carried by a crank arm 22' at the end of the plug 9.

The spindle 15 which carries the cam 14 is driven by an electric motor 23 which also drives the Rootes blower, the drive from the motor to the spindle 15 being effected through a pulley-cum-belt drive 24, a variable speed device 25 of the conical pulley type, and through a reduction gear train 25A.

As the spindle 15 is turned, the cam 14 causes the tube or slide 17 to rise and fall and this in its turn causes the crank arm 22' and hence the plug 9 to oscillate in the casing 4 between the positions shown in Figures 6 and 7 through the position shown in Figure 5, so effecting the change-over operation described.

Thus in the arrangement according to the invention, the form of the plug 9 and the form of the cam 14 determines the relative timing of the high and low pressure phases occurring in the duct 7, and both factors, and particularly the form of the cam, determine the rate of change between the two phases: the detachability of the cam 14 enables this timing and rate to be chosen to suit any desired "pattern" of mechanical breathing action by the fitting of an appropriately shaped cam. The periodicity of the cycles each having a low and a high pressure phase will depend on the speed at which the cam 14 is rotated and this can be selected by regulation of the variable speed device 25. In order to provide also for regulation of the maximum and minimum pressures in the high and low pressure phases, the suction and pressure ducts 2 and 3 are extended at 2', 3' in effective shunt across the valve 9 to open ends having two-way communication with the atmosphere and in which control valves 26, 27 are respectively fitted, these valves being arranged for independent operation.

It is preferred, as is shown, to limit the maximum pressure change which can occur on the intake and output sides of the pump: for this purpose, the ducts 2 and 3 can be equipped with automatic valves 28, 29 the valve 28 opening inwardly if the suction in the duct 2 increases beyond a predetermined figure, and the valve 29 opening outwardly if the pressure in the duct 3 rises beyond a predetermined value.

Instead of discharging the output of the pump to atmosphere via the duct 6, provision can be made to connect the duct to the input side of the pump so that the heat content of the air due to its compression can be transfererd to the air passing to the pump intake.

The unit shown in Figures 1 and 2 can form a mounting for an instrument and control panel, the panel providing a mounting for the controls for the apparatus and instruments to indicate the values of the variables regulated by the controls.

Apparatus according to this invention enables the various conditions which arise in the use of mechanical breathing apparatus to be met in a simple fashion and by the use of parts which are little liable to derangement.

The action of the mechanism is that of enabling the flow of air set up by a pump to be variably drawn upon to produce the mechanical breathing action to suit any particular case.

We claim:

1. Mechanism for setting up a pulsating air supply to a mechanical breathing apparatus, said mechanism comprising a constantly running positive displacement air pump having a suction duct and a pressure duct; a discharge duct for connection to the breathing apparatus; phasing valve means for connecting said discharge duct alternately to said suction duct and said pressure duct; means for operating said phasing valve means in constantly recurring cycles; and other valve means for controlling two-way communication between the atmosphere and both said suction duct and said pressure duct independently of said phasing valve means.

2. Mechanism as set forth in claim 1 including means for varying the speed of said phasing valve operating means, and pressure operated means for regulating the pressures in said suction duct and said pressure duct respectively.

3. Mechanism as set forth in claim 1 in which said phasing valve means comprises a valve plug having a part operable for connecting said suction duct alternately to the atmosphere and to said discharge duct, and a part operable for connecting said pressure duct alternately to said discharge duct and to the atmosphere.

4. Mechanism as set forth in claim 1 in which said phasing valve means comprises a valve housing having a connection to said suction duct, a connection to said pressure duct, a connection to said discharge duct and a connection to the atmosphere, and an oscillatable valve plug in said housing; and variable speed means for oscillating said valve plug to control communication between said connections.

5. Mechanism as set forth in claim 1 in which the phasing valve operating means comprises cam mechanism including an interchangeable cam, and variable speed means for operating said cam.

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