

INSTRUCTIONS FOR MOD. RV SERIES SMALL ANIMAL VENTILATORS

VOLTEK ENTERPRISES

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Authored by: George Volgyesi

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Introduction

The trend today in medical equipment design is the increasing use of microprocessors relying on digital technology. Equipment utilizing microprocessor control can be mass produced cheaply but suffers from several serious disadvantages. For the sake of reducing manufacturing costs, modern monitors contain a minimum of controls, usually in the form of a menu-driven touch-pad, where setting operational parameters consists of going through various check-lists on different screens. Parameter changes often involve interrupting normal operation and going through several digital manipulations, sometimes taking several seconds, even for the simplest adjustment. Since all control functions are microprocessor driven, any glitches in the microprocessor or the software are usually enough to make the entire system inoperative. Repairing such equipment is not intuitive and usually involves replacing entire circuit boards, touch-pads or displays.

Older technology, using discrete modular controls and switches, may be more expensive to produce and may be physically larger, but possesses several major advantages over its modern cousins. It is conceptually more intuitive, provides more tactile feedback and parameter adjustments are instantaneous. Another advantage is the fact that analog controls provide an infinite number of settings, whereas digital controls are limited by the resolution of the analog to digital conversion.

The biggest advantage of discrete modular control over microprocessor control, in our opinion, is the ease of switching from one mode of operation to another seamlessly and instantaneously.



Overview

The RV series of small animal ventilators, designed and manufactured by Voltek Enterprises Inc., are the product of several years of research and development and are undergoing improvements continuously*. These self-contained ventilators function well with small animals weighing from 10 to 200 g. High quality research data may be obtained without external flow and pressure transducers. All operational controls and switches required to set the ventilator are logically arranged on the front panel and may be altered at any time without interrupting ventilator function. Inspired Tidal Volume is continuously displayed on a dedicated digital panel meter, while Respiratory Rate, Inspiratory Flow or Airway Pressure can be selectively displayed on a second panel meter. Continuous analog outputs of pressure, volume and flow are also available on the back panel of the ventilator for connecting external display devices or data acquisition. The newest models (RV6 and up), in addition to the other parameters, also provide digital display and analog output of Mean Airway Pressure. Other advanced features may be incorporated into the ventilator on request.

* Older models may be updated on request to the latest version for minimal cost

Specifications

MODES OF VENTILATION

1. Volume Controlled
2. Pressure controlled

TIDAL VOLUME

2 ranges selectable from front panel, set by calibrated rotary dial, displayed on a digital panel meter

Low range: from 0 to 1ml with 0.01ml resolution.

High range: from 0 to 10 ml with 0.1 ml resolution

RESPIRATORY RATE

With volume controlled, timed expiration mode: 15 to 200 BPM,

With PEEP expiration mode: depends on resistance and compliance

END EXPIRATORY PAUSE

0 to approx 4 seconds, set by non calibrated rotary dial (range can be changed on request)

INSPIRATORY FLOW

Controllable from the front panel by varying the driving pressure from 0 to 30 PSI, corresponding to inspiratory flow from 0 to approx. 6 ml/s.

PEEP

PEEP can be set from the front panel from 1 to 100 cm H₂O in the PEEP terminated expiration mode in 1 cm increments. In this mode, however the respiratory rate depends on the PEEP setting and therefore cannot be independently controlled.

If both tidal volume and respiratory rate must remain constant, external PEEP can be used.

ANALOG OUTPUTS

BNC connectors on back panel for Flow, Volume and Pressure signals for connecting to a strip chart recorder or to a data acquisition system.

SIZE: Width = 12", Hight = 5", Depth = 8"

IMPORTANT

Please familiarize yourself thoroughly with the operation of the ventilator before actually connecting it to a live animal. The easiest way to learn the functions and operation of the ventilator is to ventilate a dummy lung or water-displacement plethysmograph and play with all the controls. Observing the effect of control changes on flow, volume and pressure waveforms on a stip-chart or computerized data-acquisition system makes the practice session more instructional.

Operation

The following steps are suggested to make the ventilator functional:

1. CONNECT COMPRESSED GAS in the range of 20-50 PSI to the “AIR” inlet at the back of the ventilator.



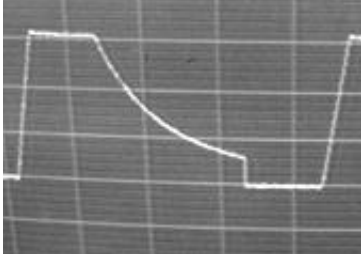
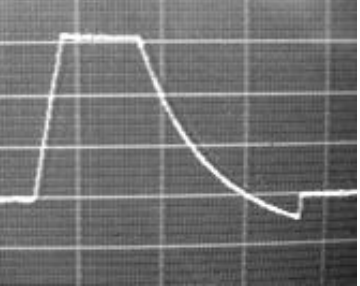
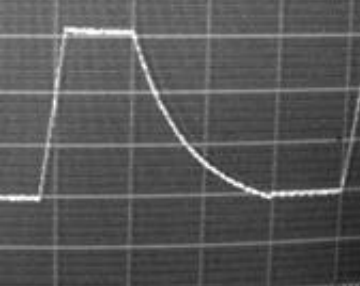
2. Turn Power switch to ON.



3. SET INSP. FLOW by first placing the selector switch to read AIR PRESS and then adjusting the INSP FLOW control to read around 20 on the monitor.
4. Set CYCLE to “VOLUME”.
5. SET TIDAL VOLUME to 0.5 ml
6. Set EXP. to be PASSIVE and TIMED (about 3s)
7. Set MODE to AUTO
8. If all is well you should hear the rhythmic clicking sounds of solenoid valves inside the ventilator.
9. Connect the airway connector to the dummy lung or plethysmograph.(FIG.6)
10. Experiment with all the different controls to get familiar with them and learn their function. When you are comfortably familiar with the ventilator, you are ready to start working with real live animals.

ADJUSTING THE EXPIRATORY FLOW GAIN CONTROL

The expiratory flow may be calibrated by turning the exp. flow gain control at the back right side of the ventilator while observing the volume waveform. If the control is turned counter-clockwise (observing from the front), the gain increases, while clockwise it decreases.

<i>Gain is too low</i>	<i>Gain is too high</i>	<i>Gain is properly set</i>
		
<p>If the gain is too low, the expiratory volume remains above the baseline.</p>	<p>If the gain is too high, the expiratory volume is greater than the inspiratory volume, so the expiratory volume waveform goes below the baseline.</p>	<p>When the expiratory flow gain control is set properly, the expiratory volume is equal to the inspiratory volume, so the expiratory waveform ends up at the baseline.</p>

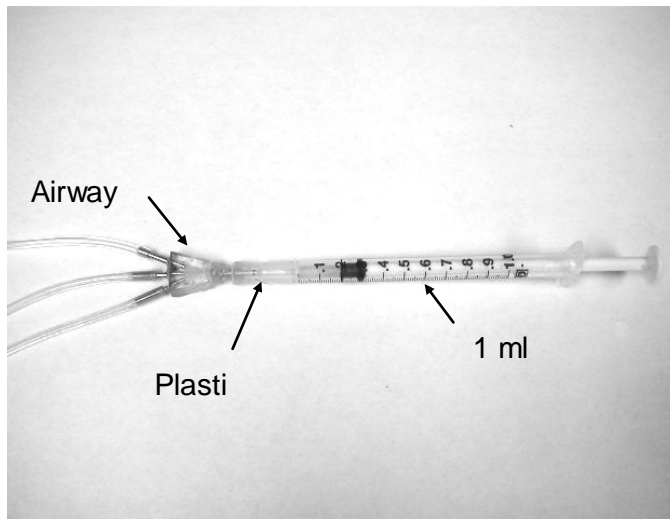
When the control is adjusted as described, both the flow and volume are calibrated.

The assumptions made are:

1. The respiratory system is in equilibrium
2. The respiratory quotient is 1
3. there are no leaks in the respiratory circuit

Note: Although the foregoing calibration should not normally effect the mechanical operation of the ventilator, it is advisable to set the flow gain to its minimum position when the expiratory flow or volume is not required for monitoring. This may prevent the integrator from “locking up” under some rare circumstances.

ACCURATE DETERMINATION OF DELIVERED TIDAL VOLUME



To determine the volume trapped in the compressible deadspace of the circuit, which is not actually delivered to the subject during inspiration, connect a small syringe containing a specific volume of air to the airway connector with a short piece of plastic tubing, as shown on the above diagram.

Place the monitor switch to read the airway pressure and the MODE switch to MANUAL. Depressurize the circuit by momentarily operating the manual EXP. Switch. Slowly inject air into the circuit from the syringe until the airway pressure reads 10 cm H₂O. By

noting the volume of air injected required to raise the pressure to 10 cm H₂O, the portion of tidal volume contained in the compressible deadspace of the ventilator can be determined for any airway pressure. For example, if the volume required to raise the airway pressure by 10 cm H₂O is found to be 0.05 ml and the plateau pressure during ventilation is 20 cm H₂O, the actual tidal volume delivered to the subject is equal to the set tidal volume minus $20/10 \times 0.05$ ml (set tidal volume - 0.1 ml).

This method permits the actually delivered tidal volume to be calculated accurately.

If the tidal volume is greater than 0.3ml, such accuracy is normally not required.

Another method for the accurate determination of delivered tidal volume involves the use of a water-displacement plethysmograph. (FIG. The water level can be adjusted to provide similar end-inspiratory plateau pressure to that obtained in the subject and the actual tidal volume can then be accurately determined by noting the difference in water level between end-expiration and end inspiration.

NOTE: ACTUALLY DELIVERED TIDAL VOLUME = SET TIDAL VOLUME – VOLUME TRAPPED IN THE COMPRESSIBLE DEADSPACE OF THE VENTILATOR.

In real life we have to compromise between the smallest deadspace and the smallest expiratory resistance. If we reduce the volume of the expiratory tubing, for example, the expiratory resistance goes up which may lead to dynamic hyperinflation. If we, however, decrease the expiratory resistance by increasing the caliber of the expiratory circuit, the delivered deadspace may be significantly smaller than the required (set) tidal volume.

DISASSEMBLING THE SOLENOID VALVES

If some secretions accidentally enter and solidify in the expiratory solenoid valve, the ventilator may become dysfunctional and the valve has to be cleaned. The following pictures illustrate the disassembly of a solenoid valve.

IMPORTANT: Do not open the ventilator without first disconnecting the power cord.



The 2 halves of the valve are held together by a metal ring which needs to be unscrewed counter-clockwise.



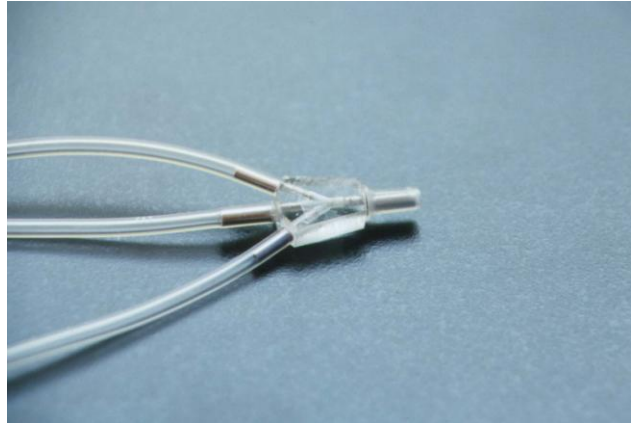
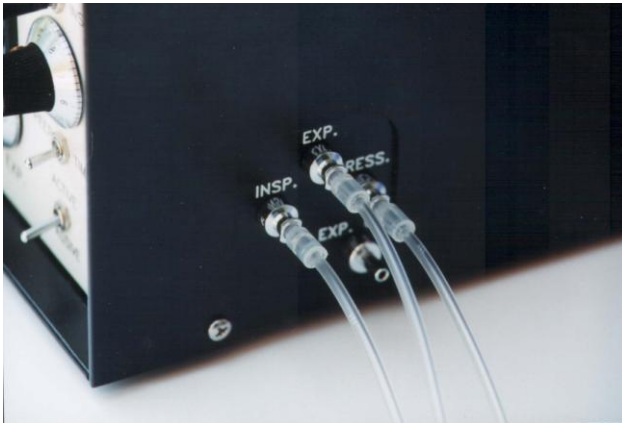
When the ring is loosened by unscrewing, the top half of the solenoid can be separated from the bottom half by pulling upward.



The bottom half of the solenoid valve contains the spider (the only moving part) and the spacer ring, both of which have to be carefully removed before cleaning.

After cleaning and drying the orifice by blowing compressed air through it and cleaning the spider and ring, the solenoid valve may be re-assembled.

ADDITIONAL VIEWS



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