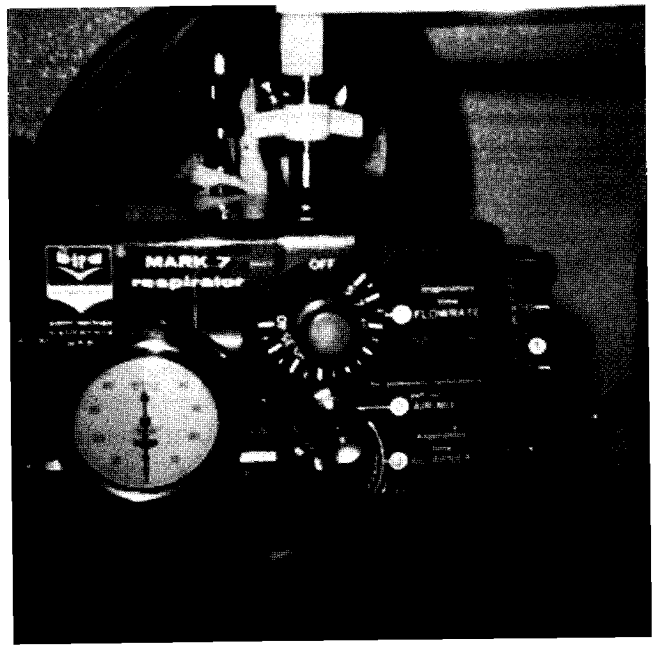

Fig. 18.52. A Bird Mark 7 Ventilator. The inspiratory-sensitivity control is on the *left* end of the ventilator, the inspiratory-pressure limit is on the *right* end, the driving gas inlet is on the *top*, and the manometer, inspiratory-flow control, air-mix selector, and expiratory-time control are on the *front* panel of the ventilator. From Lumb and Jones.[72]

6. Set the expiratory time control to establish a respiratory rate appropriate for the patient, often 8 to 12 breaths/min.
7. For final settings, the operator should understand that there are interactions between the controls on a Bird ventilator (e.g., changing inspiratory flow may affect respiratory rate).

ADS 1000 Veterinary Anesthesia Delivery System and Critical Care Ventilator

This microprocessor-controlled ventilator is marketed either for use with a vaporizer or for patients not requiring an anesthetic (e.g., critical care patients).[63] The ventilator-anesthesia system (Fig. 18.53) functions as a nonbreathing circuit, does not incorporate a bellows assembly, and does not include a canister for chemical absorbent to eliminate carbon dioxide. It is not intended for connection to another breathing system. Based on the patient's body weight, the microprocessor determines the values for the various ventilatory parameters to be provided by the ventilator.

This ventilator fits into the single-circuit class and is powered electrically and pneumatically. According to the operation manual, the ventilator must be supplied with oxygen at a pressure of 50 psi for the display to report the minute volume per kilogram of body weight accurately for the patient. Little published information other than testimonials is available about the clinical effectiveness of this ventilator system, but in vitro performance with a test lung has been studied.[64] The performance of the ventilator system in vitro changed across the range of body weights (1 to 20 kg) included in the study. Overventilation occurred at

Fig. 18.53. ADS 1000 Veterinary Anesthesia Delivery System and Critical Care Ventilator. The ports for the breathing hoses are located on the *right* side of the ventilator, and the controls for the ventilator are located on the *front* panel of the console.

body weights less than 4 kg, and underventilation was evident at body weights greater than 8 kg. The authors concluded that the ventilator could support ventilation, but the displayed parameters did not always accurately reflect the actual performance of the ventilator.

The front panel of the ventilator has the following controls and components (Fig. 18.53): power switch, mask-mode switch, set-run switch, weight-selection buttons, fill-hold button, breathe button, display for various ventilatory parameters with adjustments for these parameters below the display, and two ports for attachment of corrugated breathing tubes. Before attempting to use the ventilator, the operator should read the manual supplied by the manufacturer. The following is a summary of the manufacturer's guidelines for operating the ventilator, but is not intended to replace or supplant the manual supplied for the ventilator:

1. Connect the green oxygen hose on the back of the ventilator to an oxygen source (50 psi).
2. Attach the breathing tubes to the breathing-circuit ports on the front of the ventilator.
3. Connect the scavenger *out* port on the back of the ventilator to the hospital scavenger system.
4. Connect the electric cord to the 120-VAC–1.5-amp port on the back of the ventilator to an electric outlet.
5. Attach the vaporizer connectors to the appropriate ports on the back of the ventilator.
6. Allow the ventilator to complete the self-diagnostic test described in the operator's manual. The test will help to determine failure of the safety pop-off valve, inadequate oxygen supply, and the presence of leaks.
7. After diagnostics are complete, the mask function should be off and the set-run switch should be in the *set* position. The display will then show settings for a 20-kg patient (minute volume of 24 L/min, 9 breaths/min, peak inspiratory pressure of 15 cm H_2O, and the assist mode in the *off* position).

8. Using the weight-up or weight-down button, enter the correct weight of the patient in kilograms into the display, and the ventilator will automatically set the ventilatory parameters based on the patient's weight. Ventilation will be completely controlled (the default setting for *assist* is off).

Once these steps are completed, the patient should be anesthetized and intubated with a cuffed endotracheal tube. The Y piece connecting the breathing tubes should be attached to the endotracheal tube connector, and the vaporizer should be set appropriately. The ventilator's set-run switch should be set to *run*. Controlled ventilation should begin.

Examples of Ventilators for Large Animals

Although not all-inclusive, the following discussion includes descriptions of ventilators that are appropriate for use during anesthesia in large animal patients. Classification, principles of operation, and function are discussed.

Drager Large Animal Anesthesia Ventilator

This ventilator (Fig. 18.54) is included as a part of the Narkovet-E Large Animal Anesthesia Machine; the entire system is called the Narkovet-E Large Animal Anesthesia Control Center. The ventilator was not marketed as a stand-alone unit for large animal anesthesia. Although they are no longer being manufactured, some of these ventilator-anesthesia machine combinations remain in use in veterinary hospitals. The ventilator is powered pneumatically, generally at a pressure of 50 psi.[65] It is classed as double circuit, tidal volume preset, time cycled, and pneumatically driven with a descending bellows, and it uses fluidic circuitry. The controls include an on-off switch, a tidal volume control with a scale of 4 to 15 L on the bellows housing, a frequency control (6 to 18 breaths/min), and a flow control knob that determines inspiratory flow (a combination of flow and maximum pressure being delivered to the bellows compartment); the manufacturer recommends that the flow setting be adjusted so that the bellows always reaches the upper stop. The inspiratory to expiratory time ratio of 1:2 is preset.

Before using the ventilator, the proper connections to the gas-supply and scavenger system should be made, and the appropriate preuse checkout procedures should be done. The instruction manual for ventilators includes a standard preuse check for the ventilator.[65] The following is a logical approach to the operation of the ventilator with a circle breathing system:

1. Connect the compressed-air-supply hose to the ventilator.
2. Adjust the tidal volume control to the appropriate setting for the patient and ensure that the self-locking mechanism is engaged to prevent inadvertent movement of the bellows stop plate during use.
3. Attach the corrugated breathing hose from the bellows to the reservoir-bag port of the circle system.
4. Close the pop-off (APL) valve on the circle system.
5. Turn the power switch on.
6. Adjust the frequency control knob to the desired respiratory rate.

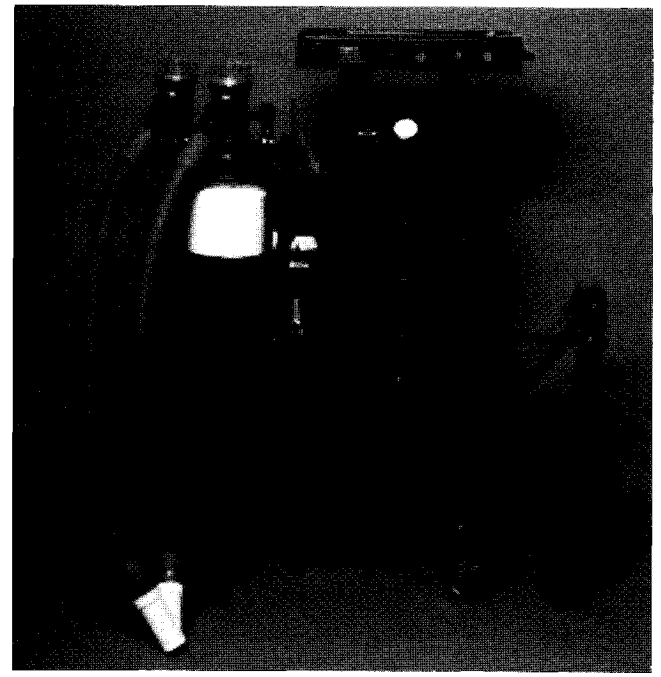

Fig. 18.54. Narkovet-E Large Animal Anesthesia Control Center: the ventilator's bellows and the bellows housing with tidal volume marking (4 to 15 L), with the large animal circle system on the *left* and the reservoir bag for the circle breathing system on the *right*. The controls for the ventilator are on the panel above the bellows housing at the *top* of the unit.

7. Adjust the flow control knob so that the bellows reaches the upper stop at end inspiration. If the bellows does not return to its original position during expiration (usually indicative of a leak in the patient circuit), the bellows can be filled by using a higher flow from the oxygen flowmeter, and the leak should be corrected.

Narkovet-E Electronic Large Animal Control Center

This is a combination of Drager's Narkovet E-2 Large Animal Anesthesia System (anesthesia machine and circle breathing system) with a Drager AV-E ventilator (Figs. 18.55 through 18.57). The ventilator is not available as a stand-alone unit for large animals and is no longer being manufactured, but machines are still in use. The ventilator is classified as double circuit, tidal volume preset, and time cycled, with a descending bellows. The ventilator is electronically controlled and pneumatically driven. It is powered electrically (120 VAC) and pneumatically (40 to 60 psi with oxygen, but air is an option).[66] The controls (Figs. 18.55 and 18.57) include an on-off switch, a self-locking knob located below the bellows assembly to control the tidal volume (4 to 15 L), a thumbwheel controller-indicator switch to adjust the respiratory rate (frequency control from 1 to 30 breaths/min), a flow control setting to determine the inspiratory flow rate, and the inspiratory-expiratory phase time ratio control (a thumbwheel indicator-controller to adjust the I-E ratio in increments of 0.5 from 1:1 to 1:4.5). The manufacturer recommends that the flow

Fig. 18.55. Narkovet-E Electronic Large Animal Control Center: the bellows and bellows housing with markings for tidal volume (4 to 15 L), the corrugated breathing hose from the bellows to the circle system (behind the bellows housing), and the self-locking knob or wheel (*bottom center*) for selection of tidal volume. In addition, the controls for the ventilator and anesthesia machine (*top* of the photograph) are included and are shown in detail in Fig. 18.56.

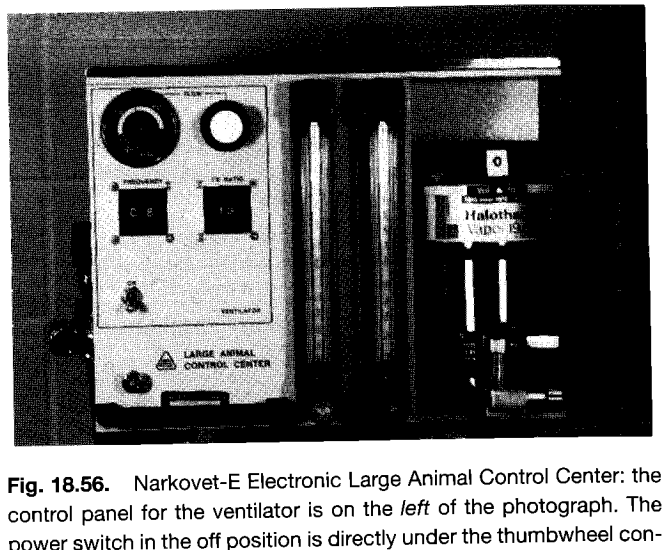

Fig. 18.56. Narkovet-E Electronic Large Animal Control Center: the control panel for the ventilator is on the *left* of the photograph. The power switch in the off position is directly under the thumbwheel controller-indicator switch for frequency (respiratory rate) selection on the *left* of the panel. The thumbwheel controller-indicator switch for inspiratory-expiratory ratio selection is on the *right* of the panel, with the inspiratory flow control directly above it. Some of the basic parts of the anesthesia machine, including the flowmeters (*center* of the photograph) for oxygen and nitrous oxide, the halothane vaporizer, and the flush valve (*bottom left*), are present.

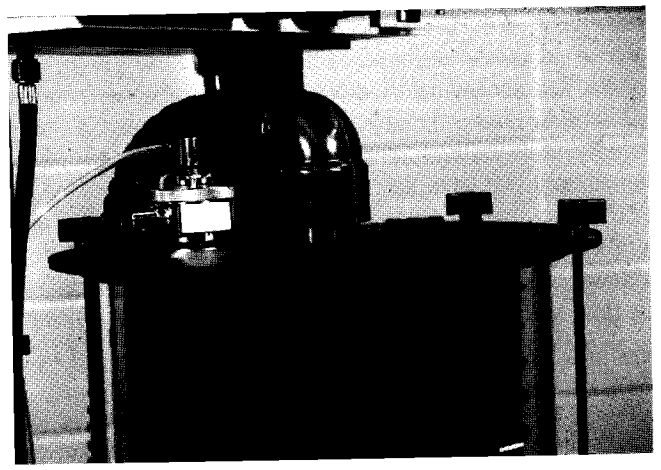

Fig. 18.57. Narkovet-E Electronic Large Animal Control Center: the top of the bellows and the bellows housing, with an elbow connecting the bellows to the corrugated breathing tube, which attaches to the reservoir port of the circle breathing system. To the *left* of the elbow is the overflow valve from the bellows, which is connected to the scavenger system from the ventilator when the ventilator is in use. The clear, small-diameter tubing attached to the pop-off valve is part of the mechanism for closing the pop-off valve during the inspiratory phase of controlled ventilation.

control knob be adjusted so that the bellows always reaches the upper stop of inspiration. The ventilator provides for controlled ventilation; assisted ventilation is not an option.

Before using the ventilator, the proper connections to the gas-supply and scavenger system should be made, and the appropriate preuse checkout procedures should be done. The instruction manual for the ventilator includes a standard preuse checklist. The following is a step-by-step approach to the operation of the ventilator with a circle breathing system:

1. Connect the gas supply (oxygen hose) to the anesthesia machine and ventilator.
2. Adjust the tidal volume control to the appropriate setting for the patient and ensure that the self-locking mechanism is engaged to prevent inadvertent movement of the bellows stop plate.
3. Select the desired frequency of ventilation.
4. Select the desired I-E ratio.
5. Attach the corrugated breathing hose from the bellows to the reservoir-bag port of the circle system.

6. Close the pop-off (APL) valve on the circle system.
7. Turn the power supply switch on.
8. Adjust the flow control knob so that the bellows reaches the upper stop at end inspiration. If the bellows does not return to its original location during expiration, it can be filled by increasing the flow from the oxygen flowmeter.

Mallard Medical Rachel Model 2800 Anesthesia Ventilator

This ventilator (Fig. 18.58) is a microprocessor-based, electronic control system that facilitates controlled ventilation in large animals being maintained on circle breathing systems (R. Pearson, personal communication, Mallard Medical, Irvine, CA).[58] The ventilator is designed to interface with currently available large animal circle systems. The stand for the ventilator and the bellows is designed for the attachment of a circle breathing system and at least two vaporizers for inhalant anesthetics, and it has shelves to accommodate physiological monitoring devices.

Most of the functional considerations for the Model 2800 are similar to those for the Model 2400V. The control console for the 2800 is located above the bellows housing instead of below the housing as it is in the 2400V, and LED displays are employed as they are in the 2400V. The ventilator is controlled by a microprocessor, but the pneumatics have been modified for generation of greater inspiratory flows, which are adjustable from 10 to 600 L/min. The bellows is inverted and ascends during expiration, and two sizes of bellows are available (3 and 21 L), allowing the selection of appropriate tidal volumes for patients with a wide range of body weights. Like other ventilators with inverted bellows, the Model 2800 produces PEEP because of the effect of gravity on the bellows. However, the amount of PEEP is controlled by a pneumatic vacuum pump on the 2800: the pump creates negative pressure between the bellows and the bellows housing during the expiratory phase of ventilation and functions to reduce the level of PEEP according to the adjustments made by the operator. An ambient end-expiratory pressure may be achieved.

Before using the ventilator, the proper connections to the gas

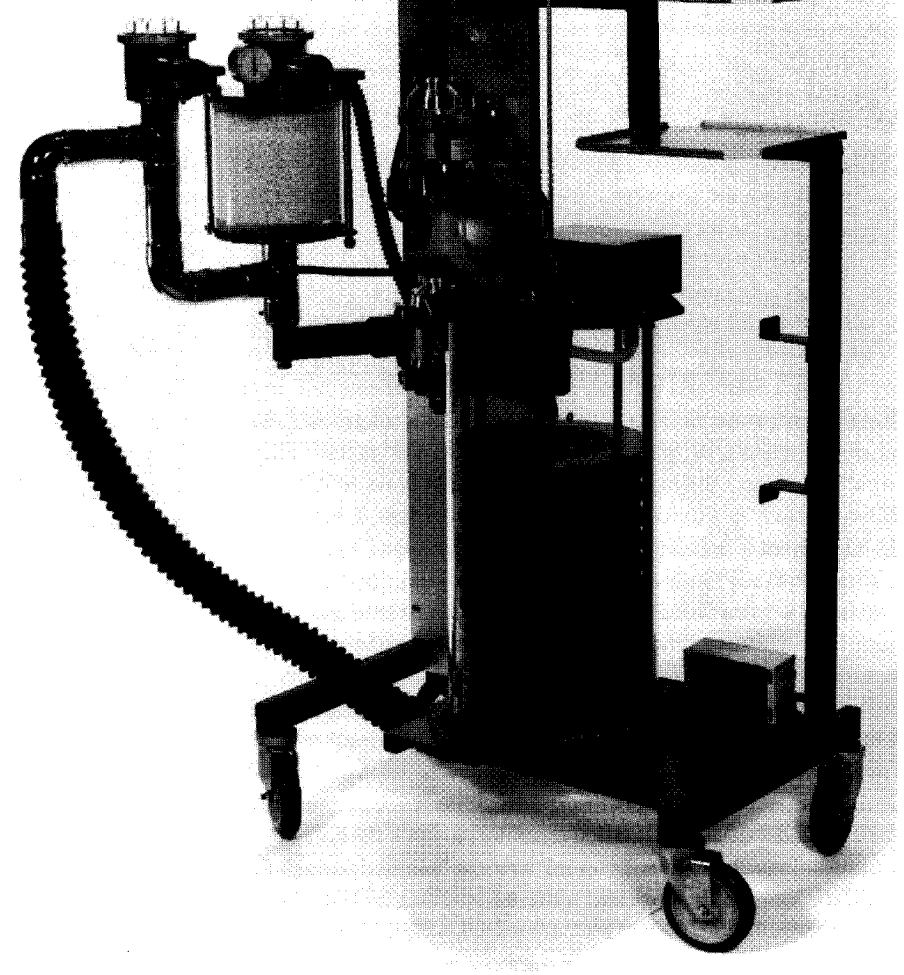

Fig. 18.58. Mallard Medical Rachel Model 2800 Large Animal Anesthesia Ventilator: the ventilator with a Matrx circle system attached (*left* side). The corrugated breathing hose that exits the bellows below the bellows housing is attached to the reservoir-bag port of the circle system. The control console for the ventilator is located at the *top* of the photograph. The controls for the 2800 are similar to those shown in Fig. 18.48 for the Model 2400V.