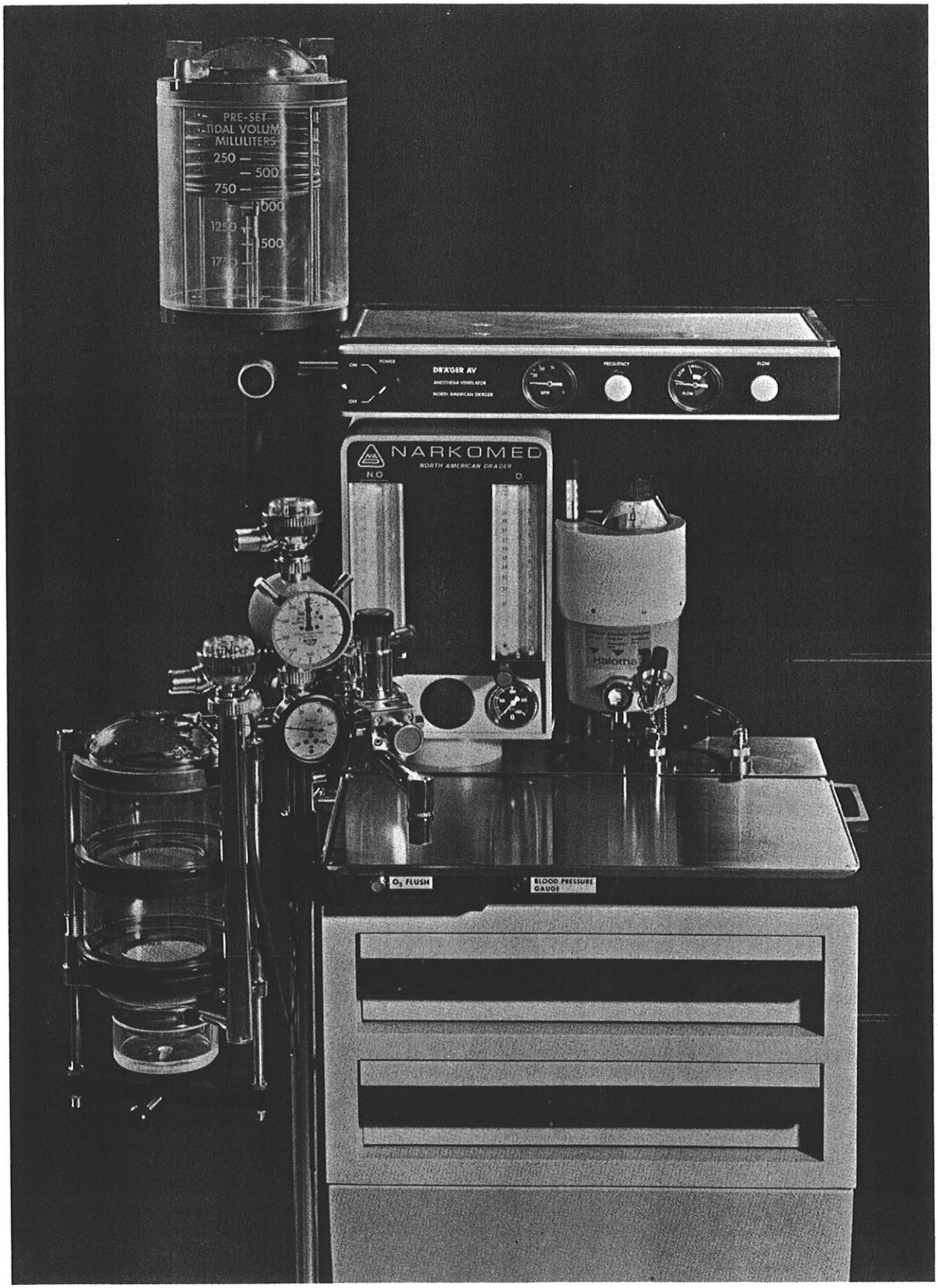
OPERATION and MAINTENANCE MANUAL

DRÄGER AV

ANESTHESIA VENTILATOR

NORTH AMERICAN DRÄGER
148B QUARRY ROAD, TELFORD, PENNSYLVANIA 18969
PH. 215-723-9824
CH8-0834 (PHILA.)

CAUTION: Federal Law restricts this Device to sale by or on the order of a Physician.


PRE-SET
TIDAL VOLUME
MILLILITERS
250
500
750
1000
1250
1500
1750
POWER
ON
OFF
DRÄGER AV
ANESTHESIA VENTILATOR
NORTH AMERICAN DRÄGER
BPM
FREQUENCY
FLOW
NARKOMED
NORTH AMERICAN DRÄGER
NO
O
Halothane
O2 FLUSH
BLOOD PRESSURE GAUGE

DRAGER AV ANESTHESIA VENTILATOR

General Description

The DRAGER AV Anesthesia Ventilator is a volume preset, time-cycled ventilator that features fluidic circuitry, independent controls, and ease of operation and cleaning. The unit acts as a controller of respiratory rate. The Inspiratory/Expiratory phase time ratio is preset to 1:2.

The DRAGER AV is recommended to be used with the NAD/AV Absorber System which incorporates a special ventilator valve having two alternate positions. In the first position (valve knob pulled toward the operator), the standard relief valve of the absorber, as well as the breathing bag, are activated and the system is ready for spontaneous breathing, or manual assisted or controlled ventilation. In the second position (valve knob pushed away from the operator), breathing bag and standard relief valve are cut out and ventilator bellows, as well as the ventilator relief valve, are activated.

The above-described arrangement offers a maximum of ease of operation and places the rebreathing bag in a most convenient location for the operator. Standard anesthesia system relief valve as well as ventilator relief valve are connected to the same exhaust gas scavenger system.

The ventilator itself is conveniently designed as a monitoring shelf and placed above the anesthesia machine. This arrangement does not take any valuable space from the operating room.

The only component of the ventilator being in contact with the patient's breathing is the bellows and the chrome-plated dome which holds the bellows. Both items can easily be removed for cleaning, sterilization, and drying purposes by disengagement of two wing nuts.

CONTROLS

1. ON/OFF

This valve controls the power supply to the ventilator. When the control is in the OFF position, the unit is not operable regardless of adjustment.

2. Tidal Volume

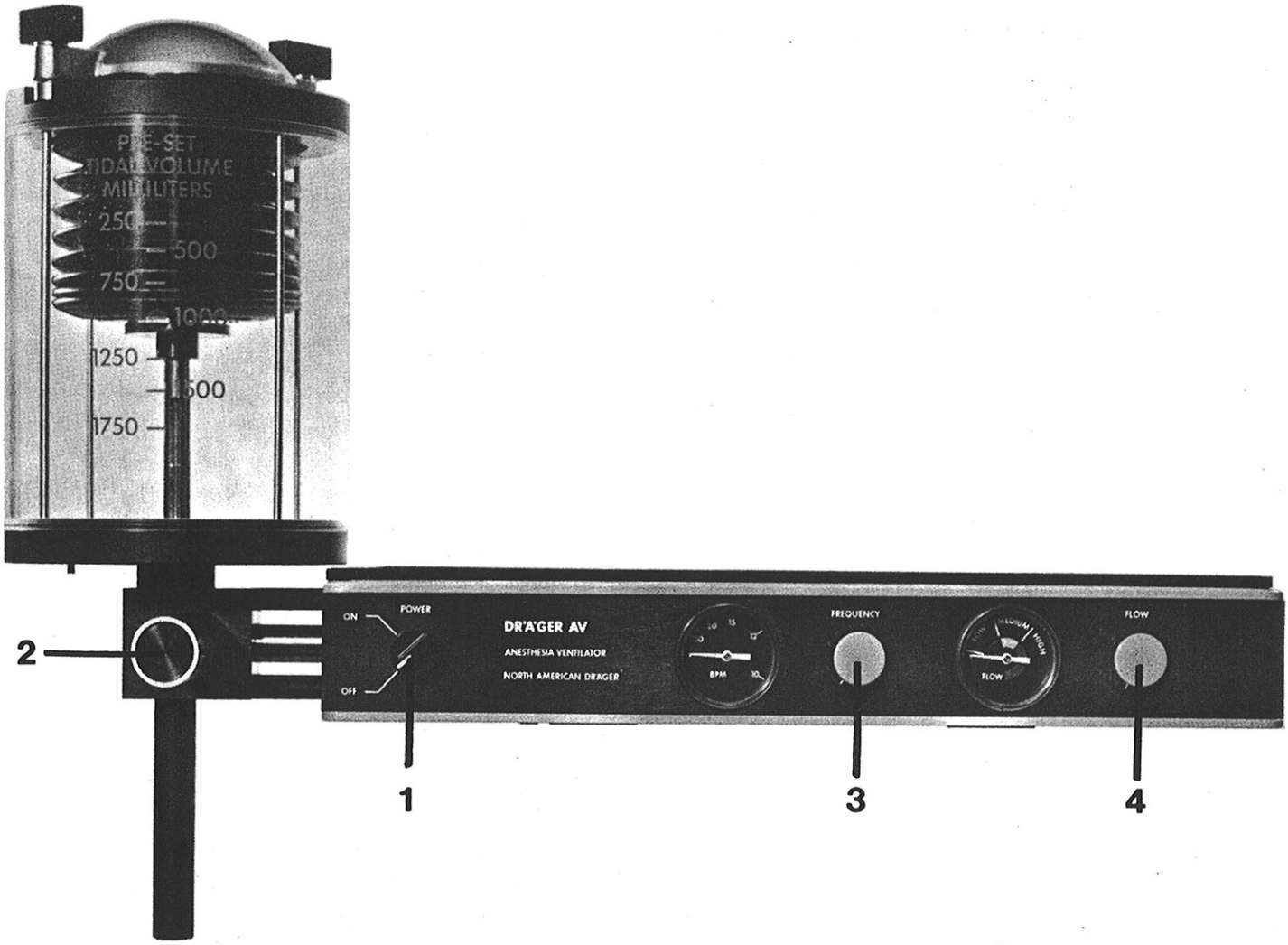
The tidal volume may be preset between 250cc and 1750cc; smaller tidal volumes can be adjusted by volume settings above minimum calibration of 250cc as well as by the easy conversion to pediatric bellows. As in any volume preset anesthesia ventilator, the actual ventilation of the lung is different from preset volume, due to the ventilation of the equipment compliance as well as the influence of fresh gas flow into the system. Exact measurements should be obtained by using a Drager MINUTE-VOLUMETER inserted in the expiratory side of the system.

3. Frequency Control (BPM)

The respiratory frequency may be preset between 10 and 30 cycles per minute; higher frequency, when desired, may be obtained with settings beyond the maximum calibration mark on the dial.

4. Flow Control

The inspiratory flow control is a combination of power flow (i.e., the flow delivered into the bellows compartment) and the maximum working pressure (i.e., the pressure which is applied to force the bellows in an upward direction). The flow setting should be adjusted so that the bellows always reaches the upper stop.



The flow gauge is divided into three zones:

GREEN	-	Low Inspiratory Flow
YELLOW	-	Medium Inspiratory Flow
ORANGE	-	High Inspiratory Flow

The <u>Indicator Needle</u> should be set
in the lower portion of
the GREEN zone
if extremely low flows are required

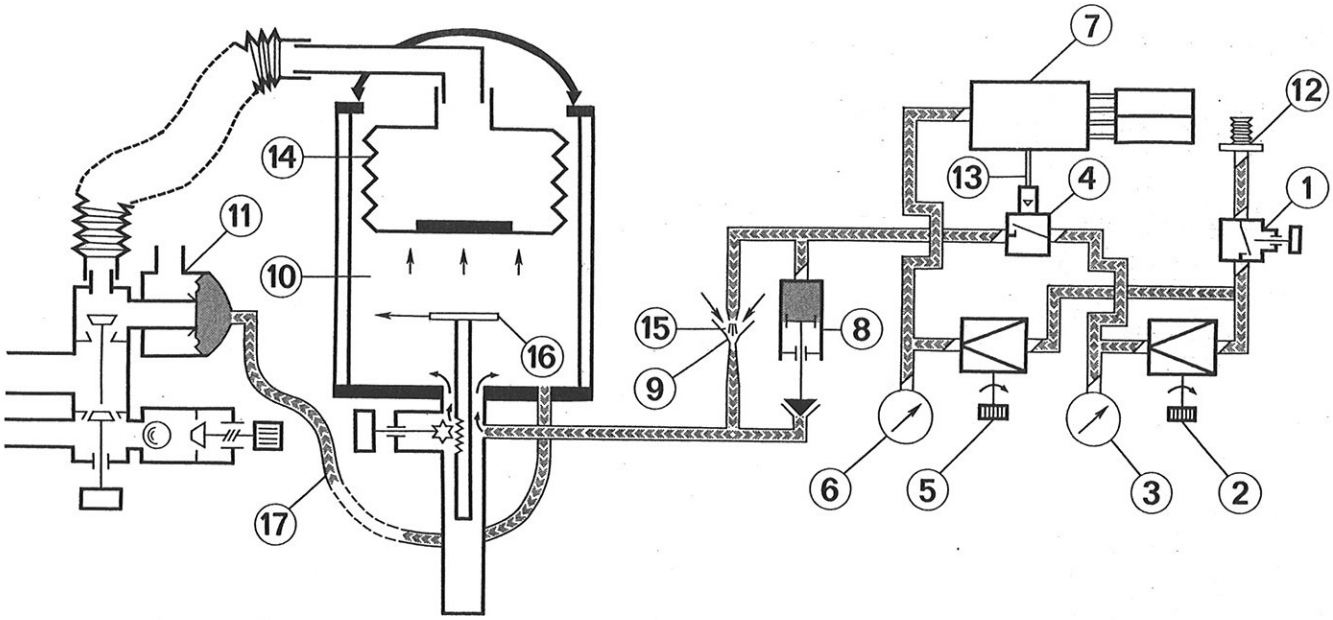


Fig. A - Inspiratory Flow Time

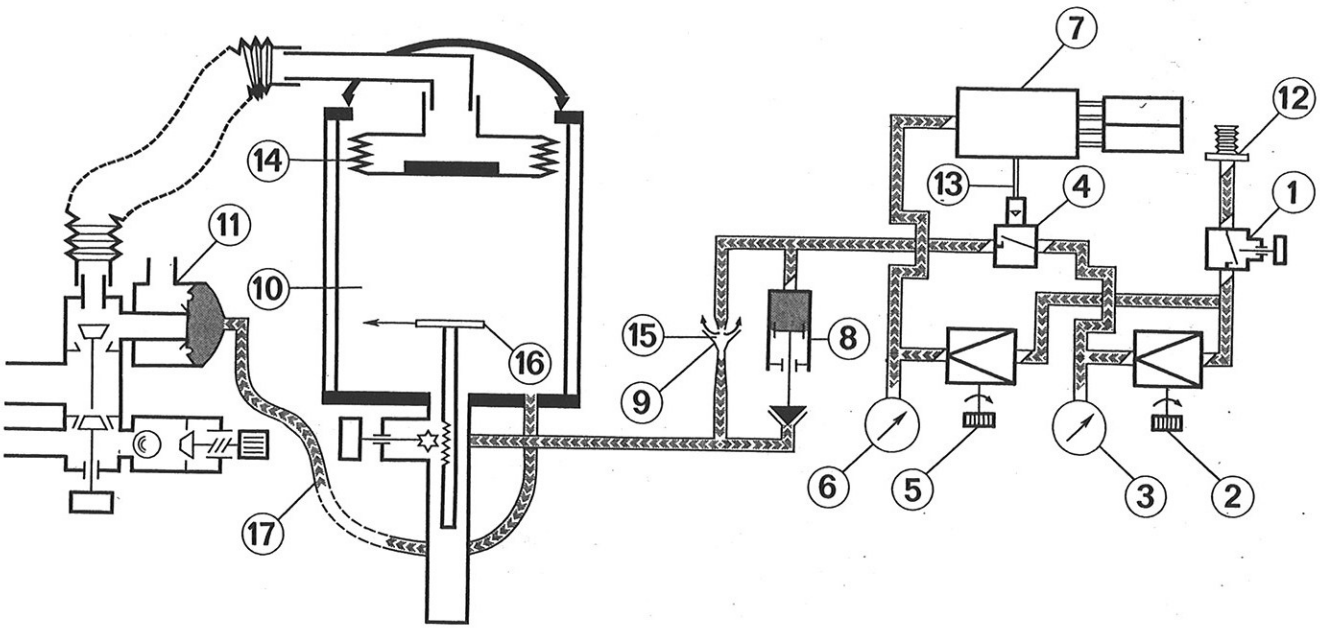


Fig. B - Inspiratory Pause Time

PRINCIPLE OF OPERATION

The power and timing circuit of the ventilator is supplied with oxygen or AIR via inlet connector (12). The pressure of this gas should be preferably between 40 & 60 psi. Reduced supply pressure, but higher than 20 psi, will not affect the functioning of the ventilator, however, will reduce the maximum respiratory minute volume obtainable. With on-off switch (1) in the open position, gas is provided to pressure regulators (2) and (5). The regulator (5) is adjustable and controls the input pressure to the fluidic timing circuit (7). An increase in input pressure will decrease the oscillation of the timing circuit and vice versa. A pilot line (13) delivers a signal to the on-off valve (4) which opens and closes the valve (4) with a frequency of the oscillation produced by the fluidic timing circuit (7). The ratio of the open time to the closed time of valve (4) is always 1:2. Due to the reproducible relationship between the input pressure to the timing circuit and the oscillating frequency, the pressure gauge is calibrated in terms of frequency (BPM). Pressure regulator (2), the so-called power flow regulator, is adjustable and controls the pressure delivered to the pilot controlled on-off valve (4). The pressure adjusted at regulator (2) is displayed at pressure gauge (3). When valve (4) is actuated by the timing circuit, gas is allowed to flow via venturi (9) into the bellows chamber (10). During the process of gas flow delivered to chamber (10) the relief valve (8) parallel to venturi (9) is actuated and closed. The increasing pressure in the bellows chamber (10) produces a pressure on the bellows and moves the bellows in an upward direction thus delivering the breathing gas contained in the bellows into the breathing system or anesthesia breathing system. The preset tidal volume of the bellows may be altered by adjusting the position of volume adjustment plate (16). The pressure within chamber (10) closes breathing system relief valve (11) by means of pilot line (17) as long as the pressure in chamber (10) is greater than the pressure in the breathing system (approximate inspiratory phase time). All the gas contained in the bellows has been discharged into the anesthesia system after the bellows has reached its upper stop, and the pressure in chamber (10) rises until it reaches a value which affects the venturi (9) in such a way that no further gas is delivered to chamber (10) but the gas provided through valve (4) is discharged to atmosphere via the intake openings (15) of venturi (9). Variance of the pressure setting of regulator (2) results in (first) adjustment of flow into chamber (10) and, thus, adjustment of the inspiratory flow, and (second) in adjustment of the maximum pressure obtained in the chamber (10). The second effect is the result of the performance characteristic of the venturi. With lower input pressure (adjusted at regulator (2)), the venturi will cease to deliver gas into chamber (10) at a lower back pressure than with higher input pressures. Pressure gauge (3), which displays the pressure adjustment of regulator (2) is divided into three zones: low inspiratory flow - green, medium inspiratory flow - yellow, high inspiratory flow - orange. At the same time, the maximum pressure in chamber (10) is limited to approximately of up to 60 cmH_2O in the upper green area, 90 cmH_2O in the upper yellow area, and 120 cmH_2O in the middle of the orange area.

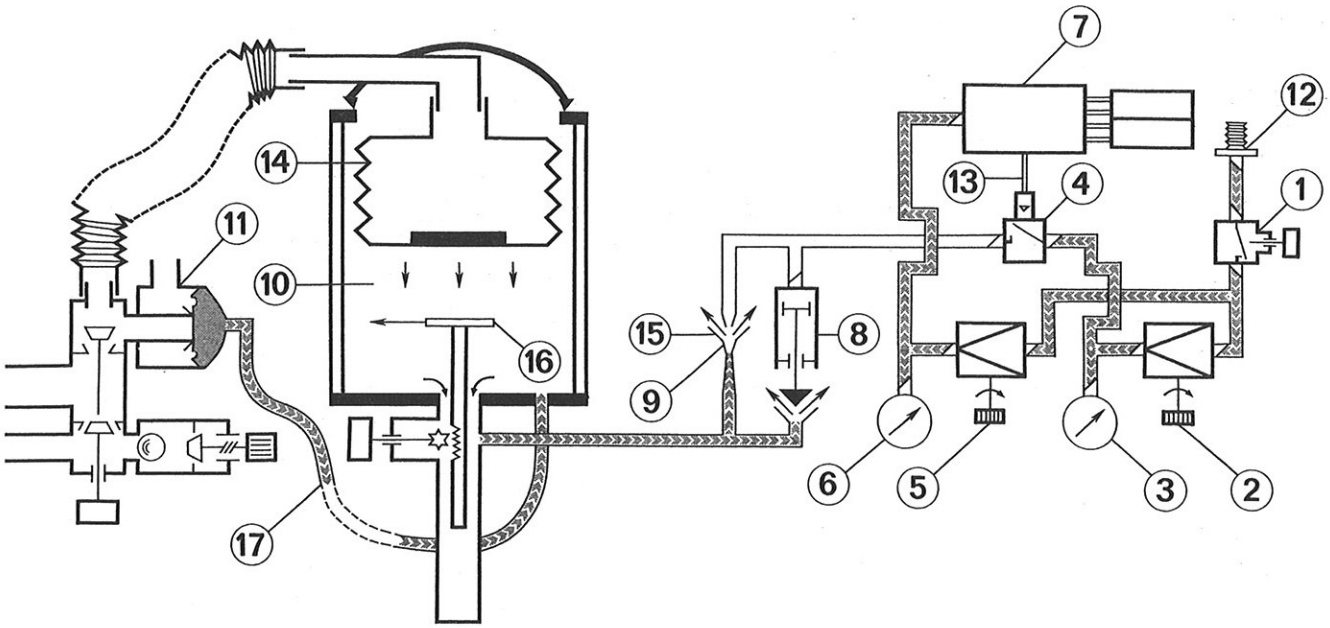


Fig. C - Expiratory Flow Time

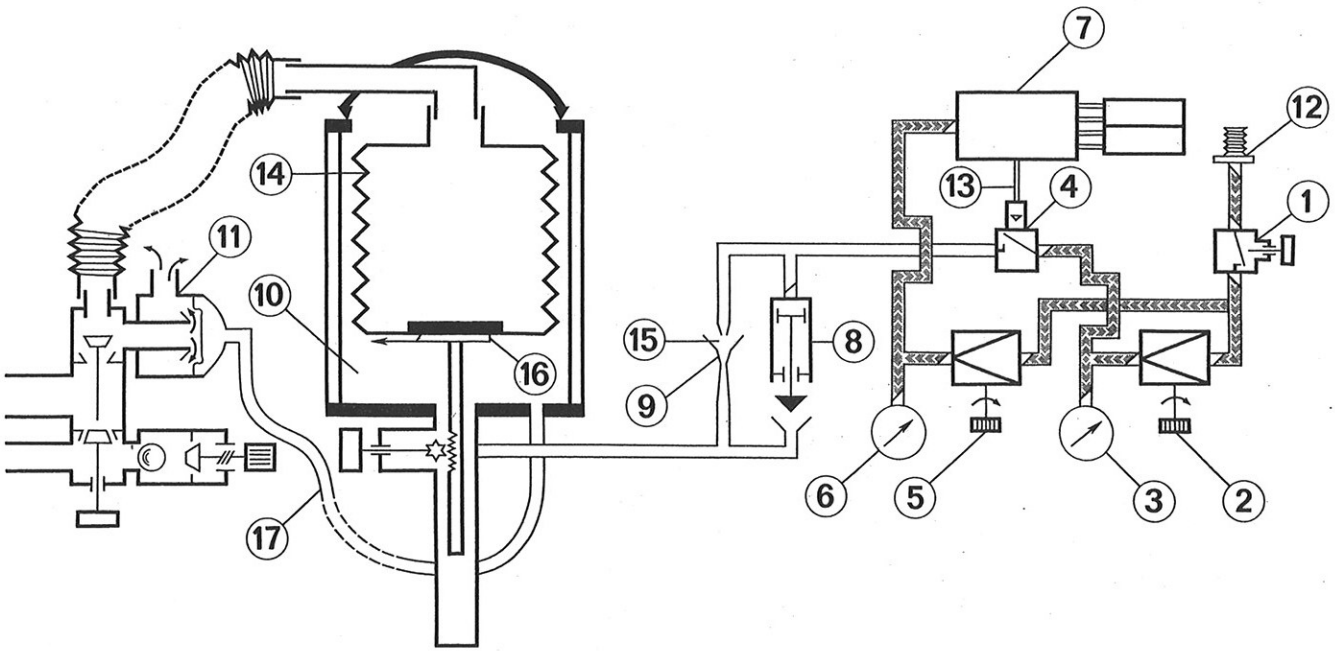


Fig. D - Expiratory Pause Time

It is known that ventilator dials cannot be calibrated in values of inspiratory flow due to the influence of such parameters as airway resistance, total lung compliance, and equipment compliance upon the flow generated by the ventilator. Therefore, we have taken the approach of indications of normal flow, high flow and extremely high flow.

The expiratory phase starts when the timing circuit (7) closes valve (4) and the power circuit relief valve (8) opens simultaneously. The pressure in chamber (10) is then released through valve (8) and bellows (14) expands until the bottom of the bellows is stopped by volume adjustment plate (16). During the expansion of the bellows the pressure in chamber (10) keeps breathing system relief valve (11) closed. The valve opens approximately when the bellows bottom has reached the lower stop and the excess gas is released from the breathing system.

PERFORMANCE

The DRAGER AV performs as a time-cycled ventilator for the change from inspiratory to expiratory phase as well as for the change from expiratory to inspiratory phase. The independent controls of frequency, generated flow, and tidal volume facilitates the performance of an inspiratory pause time when desired. Inspiratory pause time, by definition, is a period of no flow at the end of the inspiratory phase which supports distribution of gas between anesthesia breathing system and the lungs and within the lungs themselves.

Legend: for the components of the circuitry schematics (Fig. A-D)

1. On-Off Switch
2. Flow Regulator
3. Flow Gauge
4. C.A.T. Valve
5. Frequency Regulator
6. Frequency Gauge
7. Timing Circuit
8. Chamber Relief Valve
9. Venturi
10. Bellows Chamber
11. Breathing Circuit Relief Valve
12. Inlet Connector
13. Timing Circuit Pilot Line
14. Bellows
15. Venturi Intake Openings
16. Volume Adjustment Plate
17. Relief Valve Pilot Line

Legend for Diagrams: I - III D

T_{IF} = Inspiratory Flow Time;
the period of time between the beginning of inspiratory flow and the end of inspiratory flow.

T_{IP} = Inspiratory Pause Time;
the period of time between the end of inspiratory flow and the beginning of expiratory flow.

T_I = Inspiratory Phase Time;
the period of time between the beginning of inspiratory flow and the beginning of expiratory flow. This time equals the sum of T_{IF} plus T_{IP}.

T_{EF} = Expiratory Flow Time;
the period of time between the beginning of expiratory flow and the end of expiratory flow.

T_{EP} = Expiratory Pause Time;
the period of time between the end of expiratory flow and the beginning of inspiratory flow.

T_E = Expiratory Phase Time:
the period of time between the beginning of expiratory flow and the beginning of inspiratory flow. This time equals the sum of T_{EF} plus T_{EP}.

$P_{I\,max}$ = Maximum Inspiratory Pressure;
the highest airway pressure attained during the inspiratory phase.

$P_{I\,end}$ = End Inspiratory Pressure;
the airway pressure at the end of the inspiratory phase.

Upper Airway Pressure
Alveolar Pressure

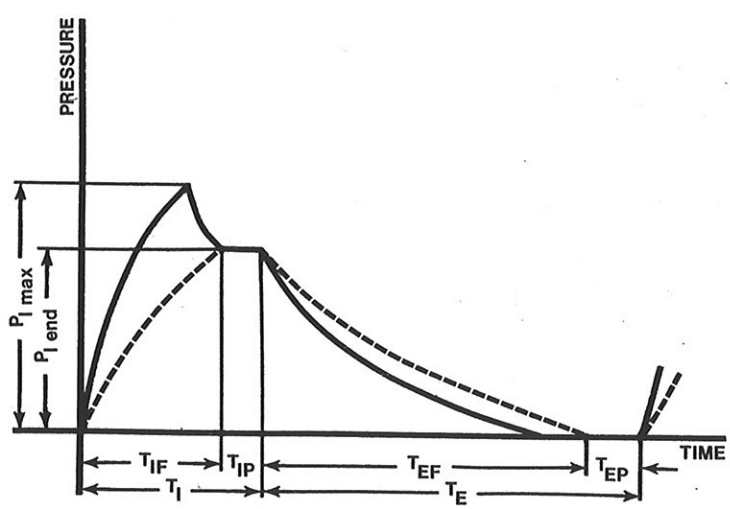


Diagram I

The pressure time diagram (I) shows a typical performance of the DRAGER AV. The solid pressure line in the diagram demonstrates the pointer movement of the system pressure gauge as a function of time. The dotted line demonstrates the imagined mean pressure within the alveoli. The volume preset in the bellows is delivered when $P_{I\,max}$ is reached. During the final period of T_{IF} an equalization of pressure between the system and the alveoli takes place resulting in a decrease of system pressure and an increase of alveolar pressure until both pressures have equalized. It should be noted that system pressure and alveolar pressure are equal during the inspiratory pause time T_{IP} facilitating the possibility to determine alveolar pressure with the system pressure gauge.

The system pressure gauge itself becomes an important instrument when used in combination with a ventilator like the DRAGER AV. The peak pressure in the system may be affected by generated flow, airway resistance, compliance and preset tidal volume. The end inspiratory pressure, when an inspiratory pause is performed, will be affected by preset tidal volume and compliance.

The influencing parameters listed above can be separated into two different groups: parameters which are changed as a result of a re-adjustment of the ventilator and parameters which are changed as a result of a change in the patient's condition.

Diagrams II and III demonstrate changes in the reading of the system pressure gauge as a result of changes in the condition of the patient or changes within the anesthesia breathing system (II A-B) and changes resulting from alteration of the ventilator controls (III A-D). The left side diagram in each case demonstrates the same original condition, while the right side diagram indicates the effect on the pressure time pattern as a result of changes in resistance or compliance (II) or ventilator adjustment (III).

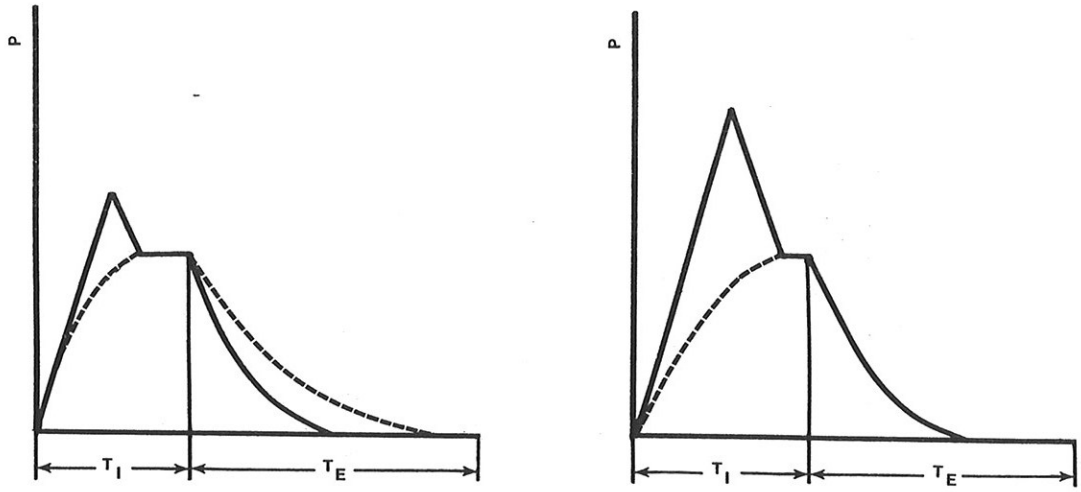


Diagram IIA

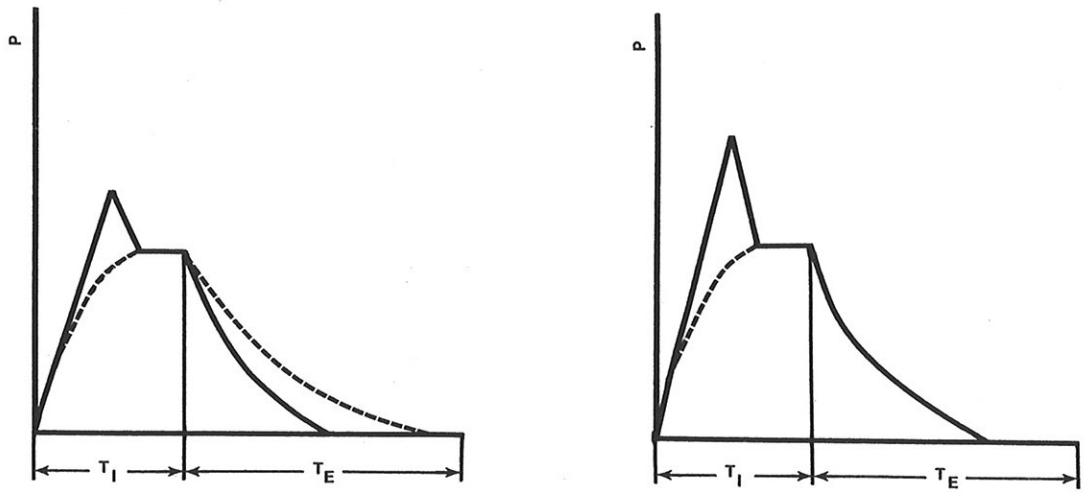


Diagram IIB

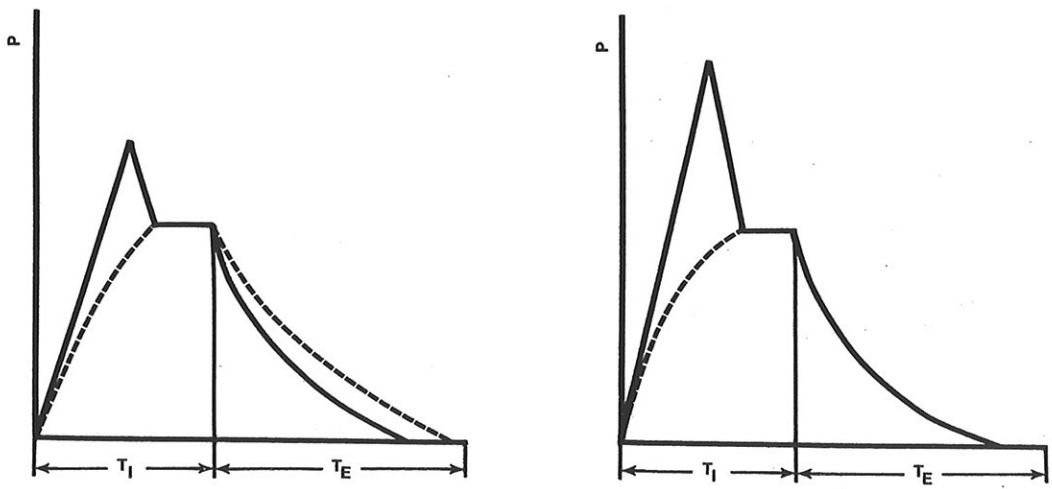


Diagram IIIA

BOEHRINGER

INSTRUCTIONS

SCAVENGING "POP-OFF" VALVE

MODEL 4844

Your valve has been designed for years of trouble-free performance. It will maintain slight positive circuit pressure (1.5 cm. H_2O) when attached to a Boehringer Laboratories' Scavenger-Vacuum Interface and will effectively conduct excess anesthetic gases to the ventilation or suction systems. Pop-off flow control is smooth, with no sudden increases in flow resistance. The valve is universally adaptable and the appropriate adapter has been included with your order.* Should any questions arise, concerning installation or care, please contact us.

Installation

1. Remove old "Pop-off" Valve.

2. Clean old seating surface to remove traces of old gasket, sealer, etc.

3. Screw new Boehringer Laboratories' "Pop-off" Valve into threaded hole as far as it will go, using gasket provided.

4. Unscrew valve a portion of a turn, until exhaust nozzle is oriented in proper direction.

5. Tighten the locking collar with the included steel rod wrench.

*Note

Some anesthetic machines will require an adapter, to allow use of our valve. If you specified other than an Ohio machine, this adapter will have been sent with your order. Most adapters require only that a gasket (included) be placed between the adapter and the "Pop-off" Valve, as shown.

1. Screw adapter into machine and tighten with a wrench.

2. Install "Pop-off" in adapter, as described above.

BOEHRINGER LABORATORIES, INC. P.O. BOX 337 WYNNEWOOD, PA. 19096

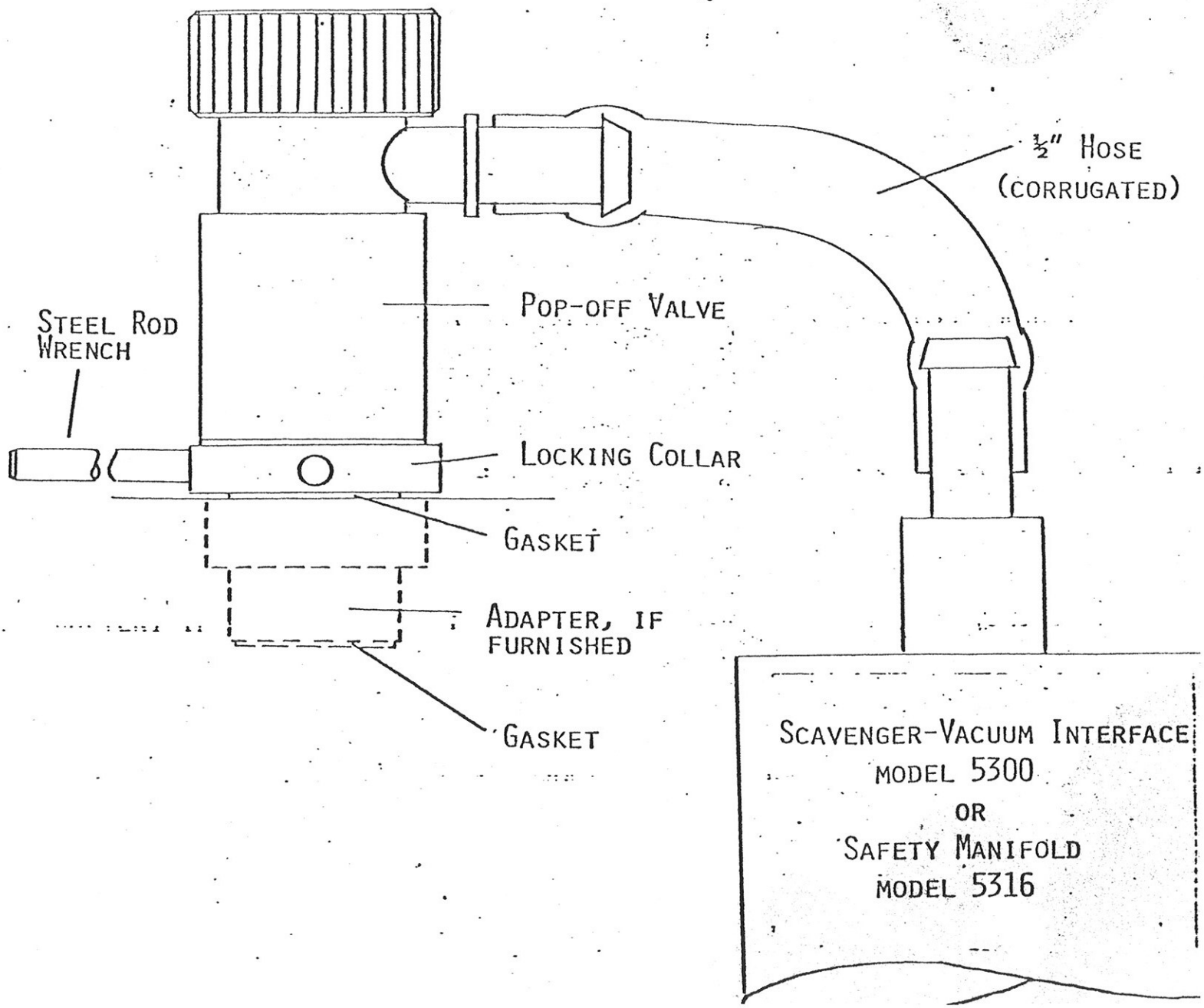
P.N. 284 03/25/77

3. Be sure gaskets are placed appropriately, to insure leak-proof operation.

The exhaust nozzle is then connected to the Scavenger-Vacuum Interface (Model 5300) or the Safety Manifold (Model 5316) by the 1/2" corrugated hose in the kit.

If you have a Foregger machine, install the adapter under the expiratory valve and attach the "Pop-off" Valve to the threaded hole provided. Remove the Foregger "Pop-off" Valve and seal the opening with the cap provided in the kit.

We strongly recommend that a monthly check of ambient air be conducted, using our Air Sampler (Model 5100) or T. W. A. Sampler (Model 5102.) Only by regular testing can you be assured that your entire anesthetic system remains leak-free and efficient.



II - Changes in Patient's Condition or Patient System

IIA

Assuming that the left side of the Diagram IIA represents an original pressure pattern of ventilation, the right side indicates an increase of resistance which may be either an increase of airway resistance or a mechanical occlusion of any other gas passage. It should be noted that increase of peak pressure as a result of increase of resistance may be accompanied by no, or little, change of pressure during the inspiratory pause.

IIB

Diagram IIB demonstrates the affect of compliance change on the reading of the system pressure gauge; such a compliance change may be the result of a change in lung compliance or total equipment compliance. It should be noted that the increase of pressure during the inspiratory pause is accompanied by a slight increase of peak pressure only.

III - Changes in Ventilator Controls

IIIA

Diagram IIIA does indicate an increase of generated flow, that means: increasing the setting of flow control knob (2). It should be noted that the increase of flow increases the peak pressure during the flow period but does not effect the pressure during the inspiratory pause.

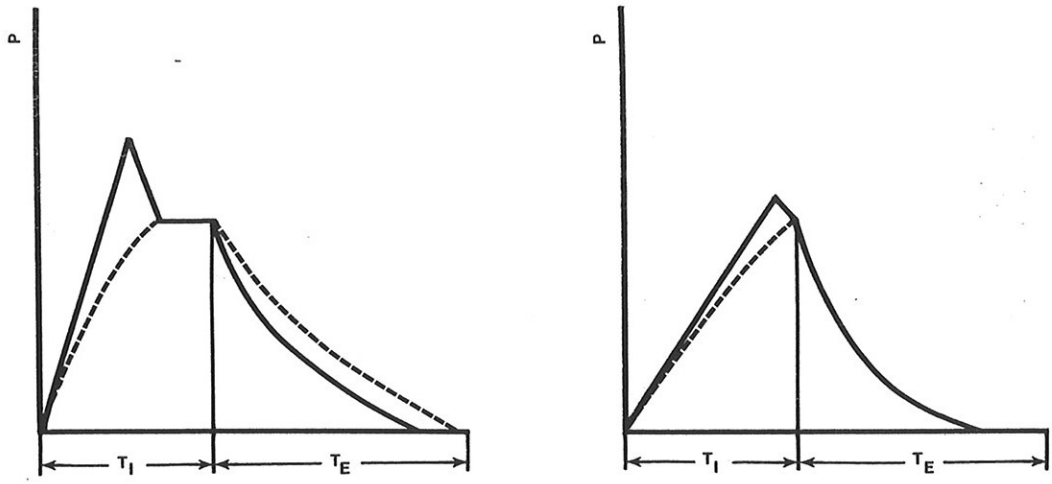


Diagram IIIB

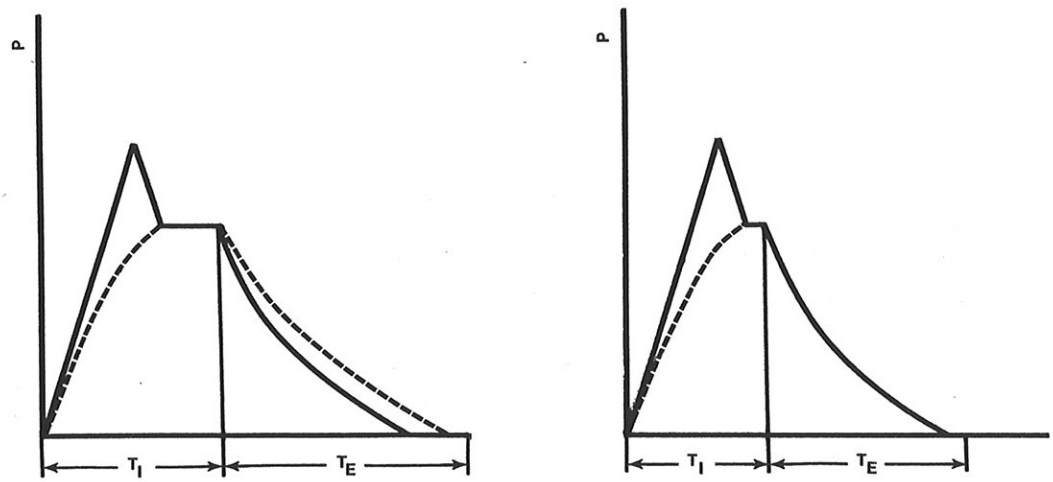


Diagram IIIC

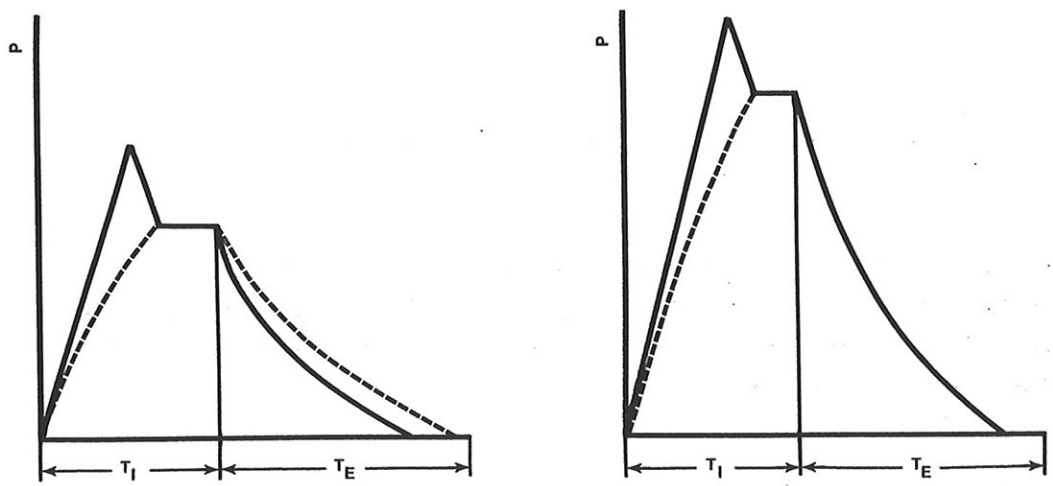


Diagram IIID

III B

To reduce peak pressure during inspiration to a minimum, the inspiratory flow can be reduced until the difference between the peak pressure and the inspiratory pause pressure indicated at the system pressure gauge becomes a minimum (III B). With such a performance, the inspiratory pause time becomes also a minimum and an unexpected increase in the airway resistance of the patient or other increase of resistance may result in a decrease of lung ventilation

III C

Diagram III C indicates an increase in frequency. It should be noted that due to independent controls of frequency, flow and tidal volume, the pressure readings during the flow portion of the inspiratory cycle are not affected by a change in the increase of frequency, however, the period of inspiratory pause is shortened in relationship to the increase of frequency. The inspiratory pause may be eliminated completely in the event of a significant increase in frequency which would require an increase of flow in order to re-establish the inspiratory pause. It should also be noted that the respiratory minute volume is increased in exact proportion to the increase of frequency when the tidal volume is kept constant.

III D

Diagram III D shows the effect on the system pressure as a result of a change in tidal volume. Both peak pressure and pressure during the inspiratory pause are increased as a result of increased preset tidal volume. An increase of tidal volume will, further, result in a lengthening of inspiratory flow time and shortening of inspiratory pause time. The generated flow may have to be increased in the event of a significant increase of tidal volume.

RECOMMENDED SEQUENCE of ADJUSTMENTS

(short form)

1. Adjust tidal volume to desired setting.
2. Turn on power switch.
3. Adjust frequency to desired frequency.
4. Set manual-automatic valve to "ventilator" position and adjust flow setting if necessary so that bellows is properly emptied (reaches upper stop).

NOTE: For emergency shut-down, turn power switch to "off" and change manual-selector valve to "bag" position.

IMPROPER FUNCTIONS & THEIR CAUSES

1. Ventilator cycles properly but bellows maintains a lower position and moves little or not at all in an upward direction.

   Probable cause & ways of elimination: Leak between bellows dome assembly and bellows housing: re-arrange bellows dome arrangement and tighten wing nuts left and right sides of bellows dome assembly. Check for proper connection of pilot light between bellows housing and anesthesia system relief valve. Check if manual automatic selector valve is in automatic position.

2. Bellows does not reach lower stop.

   Probable cause & ways of elimination: Check if sufficient fresh gas flow is delivered into anesthesia breathing system. Check for possible small leak in the anesthesia breathing system.

3. Bellows does not reach upper stop.

   Probable cause & ways of elimination: After all the measures discussed under (1) are performed, increase inspiratory flow. With maximum inspiratory flow, the ventilator should be capable of ventilating a respiratory minute volume in excess of 20 liter (frequency multiplied by preset tidal volume).

The manufacturer should be contacted immediately in all cases when the ventilator does not function properly and the cause of the improper functioning cannot be easily detected and corrected. For better understanding between our representative and the user, we have prepared a "Trouble Report" and included it on the last page of this manual. Please refer to the various points when reporting a problem or when a visit by a service representative is requested.

CHECK-OUT PROCEDURE

1. Have ventilator connected to anesthesia system.
2. Switch manual-selector valve to "ventilator".
3. Close 15mm outlet at Y-piece with thumb.
4. Adjust tidal volume to approximately 1 liter.
5. Turn on power.
6. Adjust frequency to 10 cycles per minute.
7. Adjust flow to maximum of green zone.

With the settings above, the system pressure gauge shall indicate a pressure in excess of 50 cmH_2O. If this pressure is not reached, check for leaks; refer to "Trouble Report" on page 17.

WARNINGS

1. Never operate ventilator without bellows being properly attached.

2. The unit does not incorporate a disconnect alarm; such a unit is available as an option. Proper ventilation of the patient should be observed by the action of the pressure gauge and chest movement.

3. A rotation of the indicator on the VOLUMETER should not be used as assurance of an adequately connected patient; the downward movement of the bellows may create a flow through the VOLUMETER even in the event of a totally disconnected patient.

4. Movement of the bellows shall not be used as an indicator of a tight system or a securely connected patient.

5. Fire Hazard: Never oil or grease any anesthesia equipment; oils and greases oxidize readily and will burn violently in the presence of oxygen.

6. The use of AIR as a power gas will reduce the frequency by approximately 10% against the setting of the frequency gauge.

7. Caution: Federal Law restricts this device to sale by or on the order of a physician.

CLEANING & STERILIZATION

The chrome plated dome and the bellows assembly can be heat auto-claved (120° C. maximum) or sterilized with ethylene oxide.

NOTE: Frequent heat sterilization may reduce the electric conductivity in rubber components. Periodic checks for proper conductivity are required when conductivity is necessary. The sealing gasket between chrome plated dome and bellows housing is not auto-clavable and should be removed prior to heat sterilization. Allow for proper airing time if ethylene oxide sterilization is used. Liquid disinfection shall only be used when the flushing procedure guarrantees complete removal of the remains of liquid disinfectant.

LIMITED WARRANTY

The DRAGER AV Anesthesia Ventilator is warranted by North American Drager to be free from defects in parts and workmanship for a period of one year after delivery, provided that the product is properly operated according to instructions for use and that prescribed periodic maintenance and service is performed.

Any product which proves to be defective in workmanship or material will be replaced, credited, or repaired, with North American Drager holding the option. North American Drager is not responsible for deterioration, for wear, or for abuse, or, in any case, beyond the original sellers price.

REPLACEMENT PARTS

1.	Chrome Plated Dome	1101295
2.	Adult Bellows	1101296
3.	Pediatric Bellows	8400179
4.	Gasket	1100524
5.	Corrugated Breathing Tube, 36"	9999460
6.	Tubing, 1/4" O.D.	1101888

TROUBLE REPORT
DRAGER AV

Name _____
Address _____
_____
_____

DRAGER AV Serial # _____

Purchased _____
Month/Year

Ventilator settings when trouble occurred:	If the problem is not specific to settings, please use:
on/off valve _____ frequency _____ flow _____ volume _____ selector valve _____	1. upper limit of low flow 2. frequency: 15 BPM 3. 500cc tidal volume

Attachments to ventilator outlet:
Absorber system _____
Training Thorax _____
Patient _____

Measure frequency by using stop or wrist watch and enter result: _____ BPM

Does bellows move freely between lower and upper position? _____
yes/no

What pressures are obtained at system pressure gauge?
(only when patient or Training Thorax is connected)

peak pressure _____ cmH_2O
plateau pressure _____ cmH_2O
expiratory pressure _____ cmH_2O

Disconnect ventilator hose (hose between ventilator & absorber system);
Adjust frequency to: 10 BPM
flow to: upper limit of normal flow (green area):
Connect pressure gauge to ventilator outlet: enter maximum pressure obtained at pressure gauge _____ cmH_2O

NOTES:

_____
date

_____
signed

NORTH AMERICAN DRÄGER
148B QUARRY ROAD, TELFORD, PENNSYLVANIA 18969
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SERVICE LOCATION

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