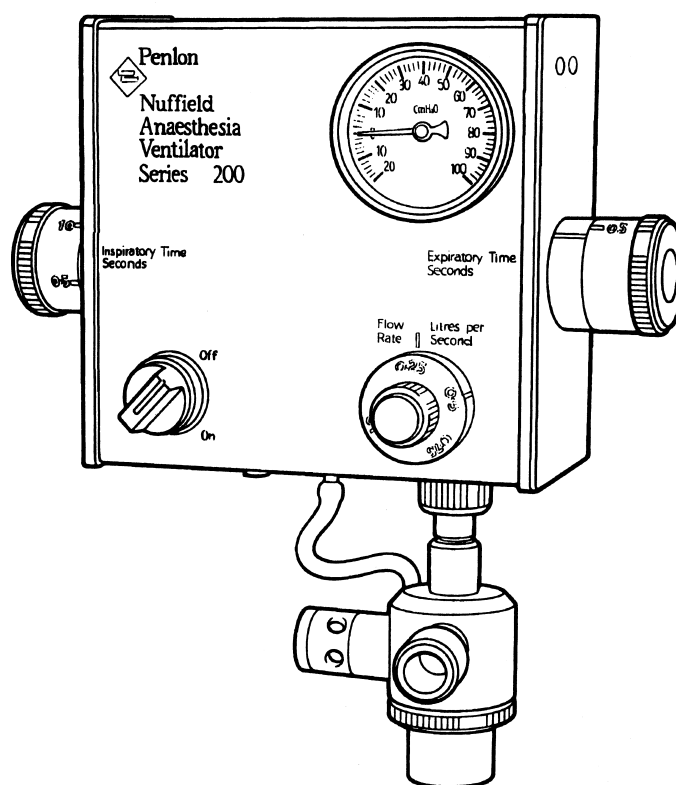


Nuffield 200 Ventilator User Instruction Manual



**Quality and Assurance in
Anaesthesia**

THE IMPORTANCE OF PATIENT MONITORING

WARNING

Anaesthetic systems have the capability to deliver mixtures of gases and vapours to the patient which could cause injury or death unless controlled by a qualified anaesthetist.

There can be considerable variation in the effect of anaesthetic drugs on individual patients so that the setting and observation of control levels on the anaesthesia systems does not in itself ensure total patient safety.

Anaesthesia system monitors and

patient monitors are very desirable aids for the anaesthetist but are not true clinical monitors as the condition of the patient is also dependent on his respiration and the functioning of his cardio-vascular system.

IT IS ESSENTIAL THAT THESE ELEMENTS ARE MONITORED FREQUENTLY AND REGULARLY AND THAT ANY OBSERVATIONS ARE GIVEN PRECEDENCE OVER MACHINE CONTROL PARAMETERS IN JUDGING THE STATE OF A CLINICAL PROCEDURE.

IMPORTANT

Servicing and Repairs

In order to ensure the full operational life of this machine, servicing by a Penlon-trained engineer should be undertaken periodically. For normal usage, we recommend a service function test every 3 months.

For any enquiry regarding the servicing or repair of this machine, contact the nearest accredited Penlon agent*, or communicate directly with:

Service and Repair Department
Penlon Limited
Abingdon
Oxfordshire
OX14 3PH
England

Telephone: 01235 547063
Fax: 01235 547062
E-Mail: service@penlon.co.uk

*Agent's name and address:

Always give as much of the following information as possible:

1. Type of equipment
2. Product name
3. Serial number
4. Approximate date of purchase
5. Apparent faults

FOREWORD

This manual has been produced to provide authorised personnel with information on the function, routine performance and maintenance checks applicable to the Penlon Nuffield 200 Ventilator.

Information contained in the Manual is correct at the date of publication. The policy of Penlon Ltd. is one of continued improvement to their products. Because of this policy Penlon Ltd. reserve the right to make any changes, which may affect instructions in this Manual, without giving prior notice.

Personnel must make themselves familiar with the contents of this Manual before using the apparatus.

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USER RESPONSIBILITY

This machine has been built to conform with the specification and operating procedures stated in this manual and/or accompanying labels and notices when checked, assembled, operated, maintained and serviced in accordance with these instructions provided. To ensure the safety of this machine it must be checked and serviced to at least the minimum standards laid out in this manual. A defective, or suspected defective, product must not under any circumstances be used.

Worn, broken, distorted, contaminated or missing components must be replaced immediately. Should such a repair become necessary it is recommended that a request for service advice be made to the nearest Penlon Service centre.

This machine and any of its constituent parts must be repaired only in accordance with written instructions issued by Penlon Ltd. and must not be altered or modified in any way without the written approval of Penlon Ltd. The user of this equipment shall have the sole responsibility for any malfunction which results from improper use, maintenance, repair, damage or alteration by anyone other than Penlon or their appointed agents.

WARNINGS AND CAUTIONS

The Nuffield 200 Ventilator is intended for use by a qualified practitioner.

Personnel operating the ventilator must become thoroughly familiar with the contents of this instruction manual prior to using the Nuffield 200 ventilator with patients.

WARNING – Means that there is a possibility of injury to yourself or others.

CAUTION – Means that there is a possibility of damage to the ventilator or other equipment.

NOTE – Indicates points of particular interest for more efficient and convenient operation.

WARNINGS

1. **Personnel must make themselves familiar with the contents of this manual and the machine's function before using the ventilator.**
2. **Before the ventilator is used clinically for the first time, verify that the hospital engineering department has carried out a performance check.**
3. **The driving gas supply must be clean and dry to prevent ventilator malfunction.**
4. **This ventilator is designed to be driven by oxygen or medical air only. It is calibrated for oxygen and the use of any other gas will cause inaccurate operation.**
5. **The breathing system which conveys gases from the anaesthetic machine to the patient and disposes of expired gases is a vital part of the anaesthetic delivery system. Because breathing systems require frequent cleaning and disinfection they are not a permanent part of the anaesthetic ventilator and therefore cannot be directly under the control of the anaesthetic ventilator manufacturer.**
However, we strongly recommend that only breathing systems which have been approved and authorized by Penlon for use with Nuffield 200 should be employed.
When mechanical ventilation is employed the patient breathing system must be connected directly to a pressure relief valve to prevent the possibility of barotrauma.
6. **Applying negative or positive pressure to the exhaust port of the patient valve results in that pressure being transmitted to the patient breathing system. Therefore the scavenging system must not generate more than 0.5 cmH₂O positive or negative pressure when connected to the ventilator.**
Any problem arising from an improperly functioning scavenging system is solely the user's responsibility.
7. **Before using the ventilator check that all connections are correct, and verify that there are no leaks.**
Patient circuit disconnects are a hazard to the patient. Extreme care should be taken to prevent such occurrences.
It is recommended that Penlon Safelok fittings are used throughout the breathing circuit.
8. **Anaesthesia apparatus must be connected to an anaesthetic gas scavenging system to dispose of waste gas and prevent possible health hazards to operating room staff. This requirement must be observed during test procedures as well as during use with a patient.**
Any problem arising from an improperly functioning scavenging system is solely the user's responsibility.
9. **When the ventilator is connected to a patient, it is recommended that a qualified practitioner is in attendance at all times to react to an alarm or other indication of a problem.**

10. In compliance with good anaesthesia practice, an alternative means of ventilation must be available whenever the ventilator is in use.
11. The Nuffield 200 is not equipped with an oxygen analyser. It is recommended that the patient oxygen concentration be monitored continuously, at or near the proximal airway with an oxygen monitor that includes high/low alarms.
12. If the drive gas supply pressure drops below a nominal 340 kPa (50 psig), patient minute volume may be reduced due to lowered flow rates.
13. The characteristics of the breathing circuit connected between the ventilator and the patient can modify or change patient ventilation.
The actual ventilation of the patient may therefore be different from set values and the specifications and parameters listed in this user manual due to breathing system compliance and leaks.
Patient ventilation must be monitored independently from the ventilator.
It is the responsibility of the user to monitor patient ventilation.
14. High and Low Airway Pressure Alarms are important for patient care. The ventilator is designed to be used with an IDP pressure failure alarm.
It is important that the distal sensing tee is properly located in the expiratory limb of the circuit between the patient and the expiratory valve.
15. Opening the control unit by unauthorized personnel automatically voids all warranties and specifications.
Prevention of tampering with the control unit is exclusively the user's responsibility; the manufacturer assumes no liability for any malfunction or failure of the ventilator if the control unit's seal is broken.
16. No oil, grease or other flammable lubricant or sealant must be used on any part of the machine in close proximity to medical gas distribution components.
There is a risk of fire or explosion.

CAUTIONS

1. Do not sterilize the ventilator control unit.
The internal components are not compatible with sterilization techniques and damage may result.
2. The patient valve requires sterilization.
Peak sterilization temperatures should not exceed 54°C (136°F) for gas (ethylene oxide), and steam autoclaving.
3. Those parts suitable for ethylene oxide sterilization should, following sterilization, be quarantined in a well ventilated area to allow dissipation of residual gas absorbed by the components.
Follow the sterilizer manufacturer's recommendations for any special aeration periods required.
4. Care must be taken not to let any liquid run into the control unit; serious damage may result.
5. Always check for correct fitment, and carry out a full function test before clinical use.

1. **PURPOSE**

The Nuffield Anaesthesia Ventilator comprises a fluid logic unit driving a patient valve. The two units are readily detachable, providing easy access to the patient valve for sterilization.

The fluid logic unit is designed and calibrated to operate at a pressure of 340 kPa (49.3 lbf/in²) using oxygen. The construction of the circuit is such that only a small portion of the gas source is used to power the logic unit, the majority of gas being used to ventilate the patient. It is therefore essential that the gas used is medically pure and free from moisture.

The patient valve directs the gas flow to and from the patient. In addition it provides a restriction to the gas, dropping the patient delivery pressure to the required level. A retention ring is readily unscrewed to remove the patient valve which can be autoclaved. (See Sterilization, Section 10).

The Nuffield Ventilator is designed to operate as a source of power, for co-axial breathing systems (Bain) and an Ayres 'T' piece in conjunction with a Newton valve. The ventilator is not designed to operate from an anaesthetic gas supply as in the case of a minute volume divider. Where anaesthetic gases are not required the Nuffield may be used as a resuscitation device using either oxygen or air.

NOTE For paediatric anaesthesia, the Nuffield 200 Ventilator may be used with the specially designed Newton Valve. (See Section 8.)

Penlon Ltd. acknowledge the assistance provided by Kay Pneumatics Ltd. and Pneupac Ltd. in the design of the pneumatic circuit for this ventilator.

Certain components are covered by patents belonging to one of other of these companies.

2. DESCRIPTION

The Nuffield Ventilator acts as a time-cycled, constant flow generator which is a pressure transformer. The functional analysis is as follows:–

Inspiratory Phase	:	Pressure transformer, constant flow generator, time and flow rate preset.
End Inspiration	:	Time-cycled
Expiratory Phase	:	Constant atmospheric pressure generator
End Expiration	:	Time-cycled

The ventilator operates only as a controller with a positive – atmospheric pressure waveform. It does not act as a minute volume divider.

The function of the ventilator, when used with an anaesthetic circuit, is to provide a controlled delivery of oxygen or air which displaces the anaesthetic gases within the breathing circuit. These gases are delivered to the patient in a manner determined by the ventilator control settings.

2.1 Pneumatic Circuit

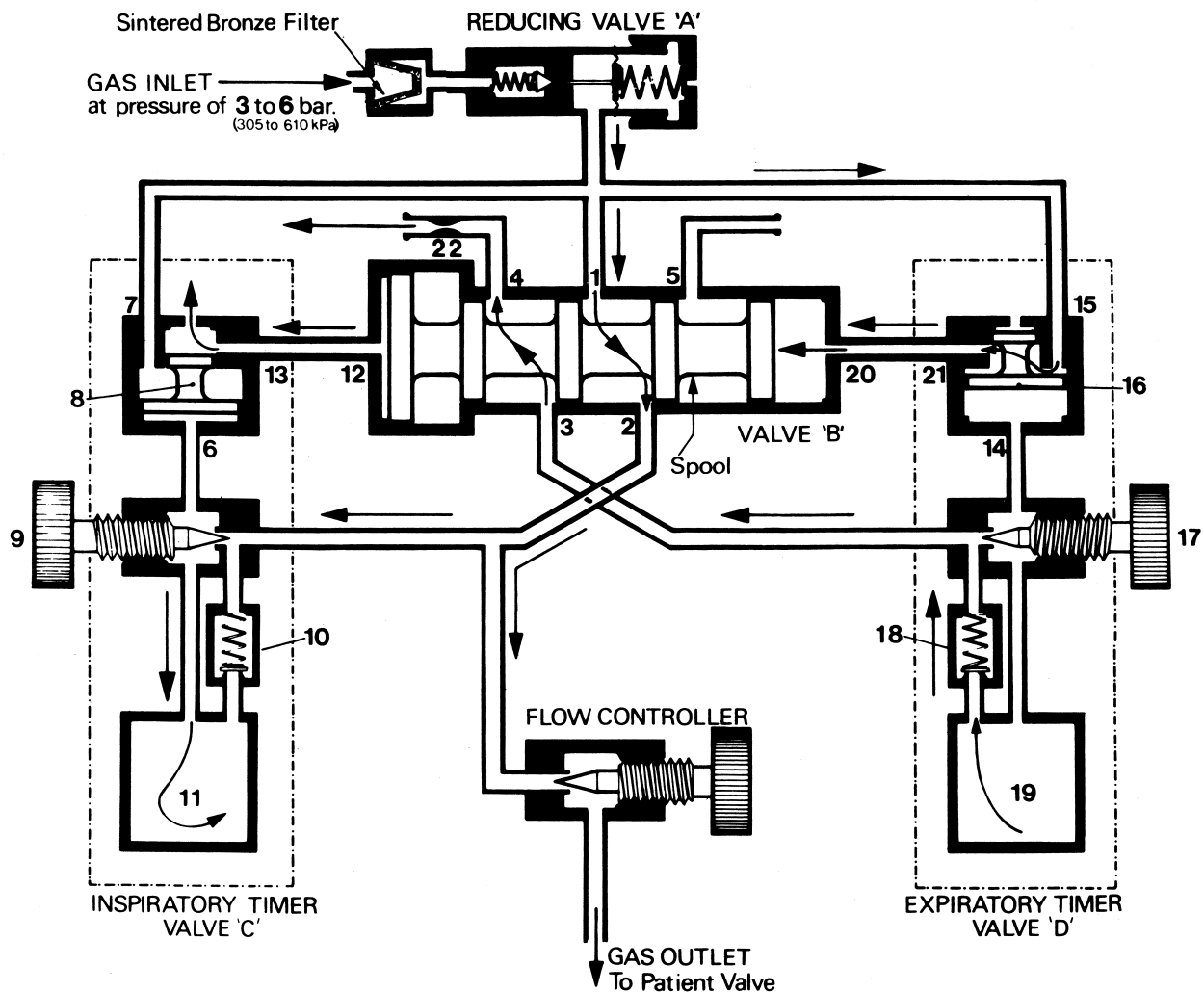


FIG. 1 PNEUMATIC CIRCUIT

The pneumatic circuit can be operated by compressed air or oxygen as all the circuit components are dry running and compatible with these gases. The source of gas supply can be from hospital pipeline, gas cylinder or air compressor, providing the gas used is free from oil and moisture.

Whilst designed and calibrated to run at 340 kPa, satisfactory performances can be derived from the ventilator on pressures ranging from 300-680 kPa. **However, with varying input pressures, variations will occur in the time settings and flow rate calibrations.**

Unless the driving gas is known to be dry, filtered and oil-free, a regulator filter unit (item 56033) is required and must be fitted to the drive gas hose. This unit should also be used if the drive gas pressure is regularly higher than 410 kPa.

On switching the ventilator to the ON position the spool in valve B is biased to one position which allows the drive gas to pass through ports 1 and 2 of the spool valve. From port 2 the gas passes to the patient, through the inspiratory flow controller, and at the same time to the inspiratory timer valve 'C'.

Flow of gas to valve C is regulated by control 9 and this in turn presets the time delay in pressure build-up on piston 8. At a pre-determined pressure level piston 8 moves to connect ports 7 and 13 to allow a pressure signal to switch the spool, via port 12, to the expiratory position. In this position port 2 is occluded and 3 opened allowing gas to pass to the expiratory timer 'valve D'. A similar sequence of operations to those on valve C, then follows until the spool is returned to the inspiratory position.

During the expiratory phase the pressure beneath piston 8 is released via the non-return valve 10, port 2 and exhausted via port 5. Likewise during the inspiratory phase pressure in valve D is released via 18, 3 and 4.

The fluid logic circuit therefore has only 3 moving parts, the two pistons and the spool, all running in special bearings, requiring no maintenance or lubrication for very long periods.

The inclusion of reducing valve A is intended to reduce the effect of increased pressure on the calibrated control settings.

2.2 Patient Valve

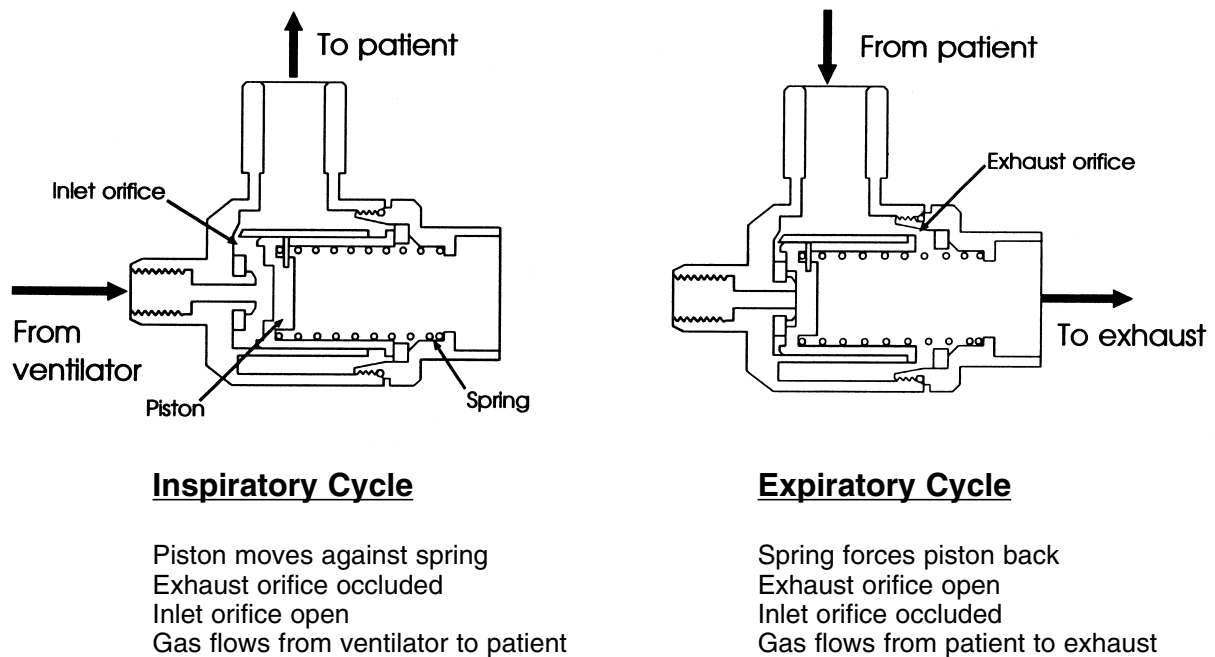


FIG. 2 PATIENT VALVE

The gas flowing from the control module to the patient valve during the inspiratory phase is at approximately the supply pressure and is reduced to a safe respiratory pressure as a result of the pressure loss characteristic of the patient valve.

During the inspiratory cycle, gas flows from the logic unit to the patient valve. Within the valve, gas is forced to flow through a small orifice causing a build-up of back pressure within the valve and reduced flow downstream of the orifice. The backpressure created, in turn forces the piston to move against the spring and occlude the exhaust port. Gas is then able to flow at reduced pressure from the small orifice and out of the “to patient” connection. A pressure relief valve (not shown) is built onto the patient valve to protect the patient against over-inflation.

When the expiratory phase commences gas flow from the logic unit is halted allowing the spring to force the piston back thus opening the exhaust port. The patient is then able to breathe back through the “to patient” connection and out through the exhaust port.

The complete patient valve is fully autoclaveable and may be readily detached from the logic unit for sterilizing procedures (see section 10).

Patient connections – 22 mm male – 15 mm female
Co-axial tapers.

Exhaust port – 30 mm ISO taper (male)

A further connection on the patient valve is included in order that a small bore hose may be connected to the manometer inside the main control module.

All patient valves are interchangeable and suitable for use on both adult and paediatric patients. **However, the piston and body of any individual valve are matched during manufacture and parts of valves must not be interchanged.**

CAUTION The patient valve of the Pneupac Resuscitator (Pneupac Limited, Dunstable, UK) is similar in appearance except that the body is black plastic. It is not suitable for use with the Nuffield 200 Ventilator. Misconnection of the resuscitation valve to the Anaesthesia Ventilator is unlikely to occur in normal use as the securing unions are quite different in design, but service technicians should be alerted to this problem if they are handling the Pneupac and the Nuffield 200.

3. SPECIFICATION

3.1	Application	Adult and Paediatric, anaesthesia and resuscitation. To be used in conjunction with standard breathing circuits.
3.2	Internal Compliance (units ml/cmH ₂ O)	
	Patient Valve	– negligible
	Patient Circuit	– dependent on type of circuit used. (Penlon Coaxial Circuit – 1.7).
3.3	Minute Volume Range	Not directly determined; it is the product of tidal volume and frequency settings At an I:E ratio of 1:2 the range is:– Max.20l, Min. 5.0l.
3.4	Tidal Volume Range	Not directly determined; it is the product of inspiratory time and inspiratory flow. Max. 2000 ml, Min. 50 ml.
3.5	Frequency Range	Separate inspiratory and expiratory controls determine the frequency. Max. 86 bpm, Min. 10 bpm ± 10% or 1.5 bpm whichever is greater.
3.6	Inspiratory Phase Time Range	The inspiratory time is independent and continuously variable from 0.2 – 2.0 sec. ± 12½% or 0.05 sec. whichever is greater.
3.7	Expiratory Phase Time Range	The expiratory time is independent and continuously variable from 0.5 – 4.0 sec. ± 12½%.
3.8	Inspiratory/Expiratory Phase Time Ratio Range	Dependent on inspiratory and expiratory control settings and continuously variable from 4:1 to 1:20.
3.9	Ventilator Pressure Control Range	Not directly determined. Maximum pressure limited by fixed relief valve set at 60 cm H ₂ O ± 10%.
3.10	Inspiratory Flow Range	The control of inspiratory flow is independent and continuously variable from 0.25 – 1.0 l/sec. ± 15%.
3.11	Inspiratory Pressure Limit	By safety valve, permanently set at 60 cm H ₂ O ± 10%. A range of spare valves is available.

3.12	Inspiratory Triggering Pressure, Flow and Volume	No Trigger.
3.13	Inspiratory Triggering Response Time	No Trigger.
3.14	Maximum Safety Pressure	60 cm H ₂ O ± 10%.
3.15	Maximum Working Pressure	60 cm H ₂ O ± 10%.
3.16	Minimum Safety Pressure	Atmospheric.
3.17	Minimum Working Pressure	Atmospheric.
3.18	Sub-Atmospheric Pressure Range	None.
3.19	Expiratory Resistance	Dependent on type of circuit used. Resistance through patient valve at 50 l/min. = 2.1 cm H ₂ O or less.
3.20	Sigh Characteristics	None.
3.21	Inspiratory	No mixture controls supplied.
3.22	Flowmeters	Calibrated inspiratory flow control provided. 0.25 – 1.0 l/sec. ± 15%.
3.23	Manual Changeover	Turn ON/OFF control to “OFF”, disconnect ventilator from circuit and ventilate as normal for type of circuit being used e.g. use breathing bag on Co-axial Circuit.
3.24	Inspiratory Relief Valve	Pre-set at 60 cm H ₂ O ± 10%.
3.25	Humidifiers and Monitors	Non supplied as standard.
3.26	System Pressure Gauge	None.
3.27	Airway Pressure Gauge	60 mm (2 ¹ / ₄ in) dial aneroid gauge scaled – 20 to 100 cm H ₂ O. Connected to patient valve by 3 mm hose.
3.28	Spirometer	None supplied. Tidal volume and minute volume should be monitored from the patient connection on the breathing circuit used.
3.29	Alarms	None supplied.
3.30	Power Source	Compressed air or oxygen at 410 kPa (60 psig), dry, filtered and oil free (Medically clean).
3.31	Power Consumption	0.1 l/cycle of control module, i.e. at 20 bpm – 2 l/min.
3.32	Dimensions	270 x 210 x 100 mm.
3.33	Weight	3.25 kg.

3.34	Method of Disinfection of Sterilization	The control module is not suitable for sterilization. Patient valve detachable for sterilization. For method see page 28, section 10, Sterilization.
3.35	Bacterial Filter	None supplied. Suitable filters for patient circuit and manometer connection (not of Penlon manufacture) available to order.
3.36	Fail-Safe Mechanism	Patient valve designed to fail in open position allowing spontaneous respiration.
3.37	(a) Mobility	Secure mounting on anaesthesia machine is required
	(b) Mounting	Brackets available as optional extras to suit various mounting systems.
3.38	Reliability	Expected life before signs of significant wear or necessary service on reciprocating parts = $6 - 50 \times 10^6$ cycles.
3.39	Environmental	
	Ambient temperature Storage	-5 to 50°C (23 to 122°F)
	Operating	10 to 38°C (50 to 100°F)
	Humidity	10-95% RH (relative humidity), non-condensing
	Altitude	Up to 2440 m (8000 ft)
	IP (ingress protection)	IP42

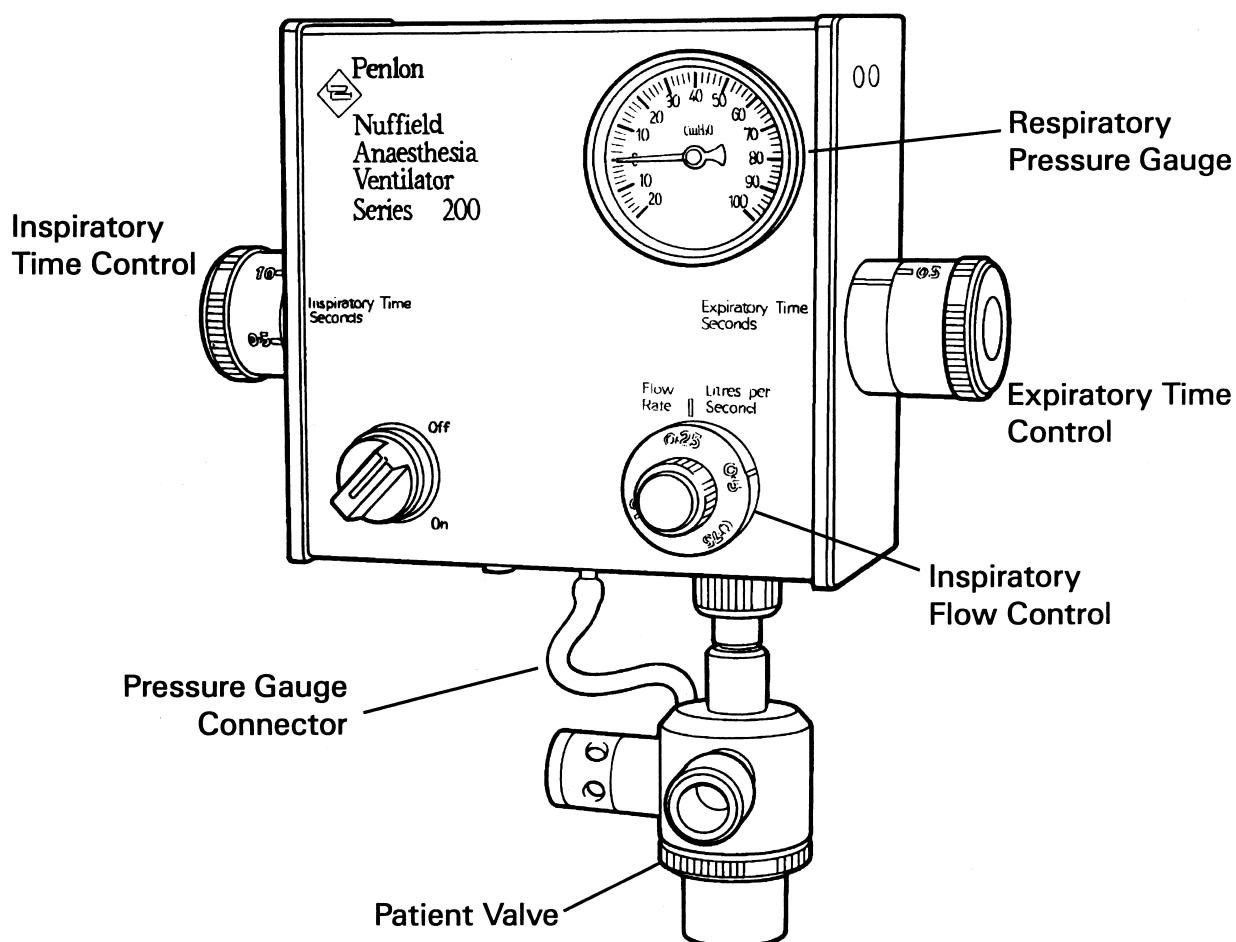


FIG. 3 CONTROLS AND INSTRUMENTS

The Nuffield Ventilator series are calibrated to give the specified performance with oxygen as the drive gas. If being operated with air as the driving gas the ventilator will run approximately 10% fast.

4.1 On-Off Control

This control is turned 90° clockwise to switch the ventilator on. The logic unit will then begin to function and will cycle until the control is turned to the "Off" position. Switching the control to "Off" will immediately stop the ventilator in either cycle. However, switching back to the "On" position, the ventilator will always start on the inspiratory phase.

4.2 **Inspiratory Control**

The time cycle of the inspiratory phase is controlled by the setting on the calibrated inspiratory control knob, situated on the left hand of the module. The inspiratory time is continuously variable from 0.2 – 2.0 sec.

4.3 **Expiratory Control**

The expiratory time is controlled with a knob sited on the right hand side of the module. The expiratory time is continuously variable from 0.5 – 4.0 sec.

4.4 **Inspiratory Flow Rate**

The inspiratory flow rate can be pre-set by using the calibrated control knob sited on the front of the module in the bottom right hand corner. This control provides a continuously variable flow rate range from 0.25 – 1.0 l/sec.

4.5 **Tidal Volume Control**

There is no direct control feature for pre-setting the patient tidal volume. However, the tidal volume can be indirectly pre-set by a combination of the inspiratory time and inspiratory flow rate. Direct multiplication of these parameters will indicate the tidal volume in litres.

e.g. If inspiratory time = 1.5 sec., and
 flow rate = 0.5 l/sec.
 then tidal volume = 1.5 x 0.5 l (750 ml)

4.6 **Pressure Relief Valve**

A pressure relief valve is fitted to the patient valve and pre-set at a fixed relief pressure. The standard valve fitted to Nuffield units is set at 60 cm H₂O. The function of the relief valve should be checked by occluding the “to patient” port on the patient valve and turning the “On-Off” control to the “On” position. If the valve is functioning correctly the respiratory pressure gauge will indicate the relief pressure.

4.7 **Respiratory Pressure Gauge**

This is calibrated in cm H₂O from – 20 to +100 and is provided with a simple zero adjust mechanism sited at the base of the gauge. Connection is made via a nipple sited centrally on the base of the module.

4.8 Respiratory Frequency and Tidal Volume Table

The following table shows control settings to be used to obtain various common respiratory patterns with I:E ratio 1:2.

Frequency	'I' setting	'E' setting	'Flow Rate' setting	Tidal vol ml (± 15%)
13	1.50	3.00	0.25	375
			0.50	750
			0.75	1125
			1.00	1500
			<hr/>	
20	1.00	2.0	0.25	250
			0.50	500
			1.75	750
			1.00	1000
			<hr/>	

5. PREPARING THE VENTILATOR FOR USE

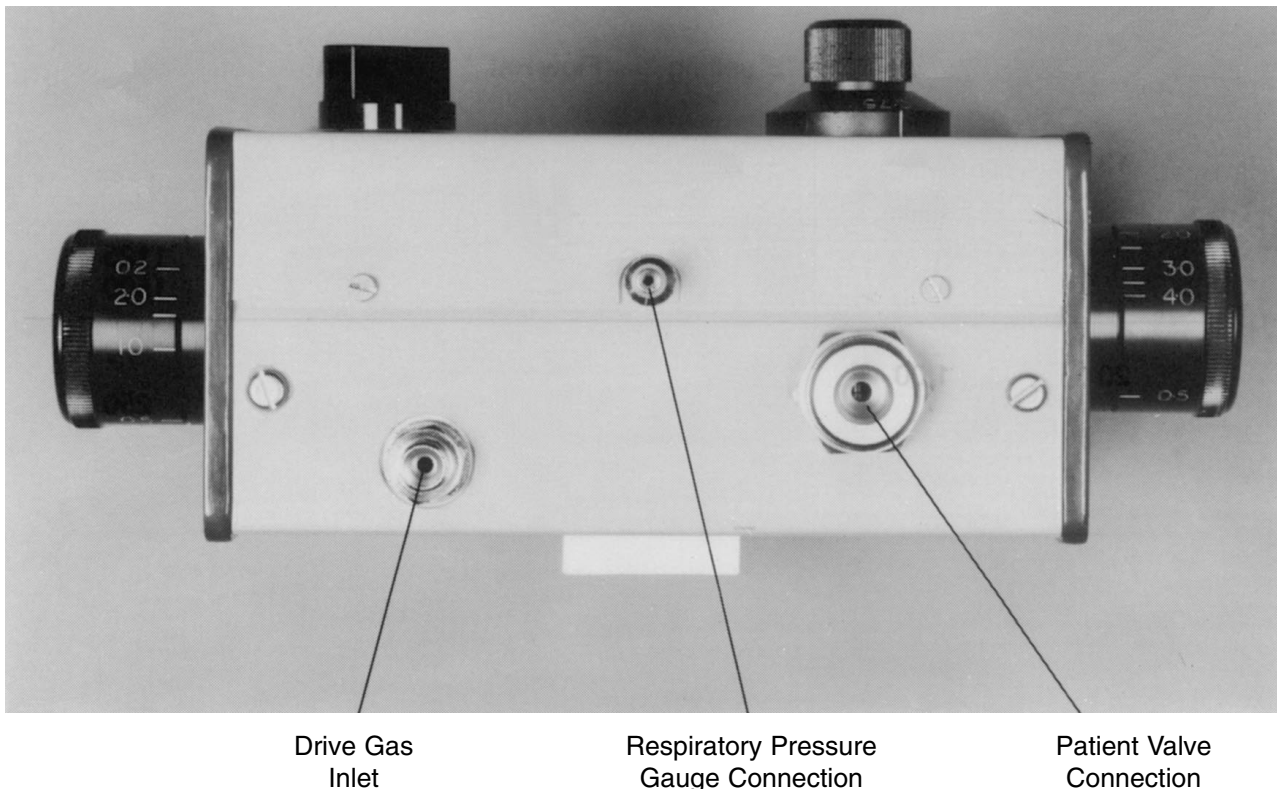


FIG. 4 CONTROL MODULE CONNECTIONS

5.1 Drive Gas Connection

The drive gas inlet is sited on the bottom face of the control module and is designed to accept 1/8 in BSP "Simplifix" compression unions (See Fig. 4) or relevant connector defined in the relevant national standard.

The ventilator is supplied with a drive gas hose as standard with suitable connections for attachment to hospital pipeline supplies or anaesthetic machines, as specified by the customer. If not specified, a 5 m hose will be supplied fitted with a standard O₂ pipeline Schraeder MkIII probe.

If compressed air is to be used as the drive gas, ensure the air is free from dirt, oil or water and medically pure. Consult the Hospital Engineer wherever possible.

Where drive gas pressures in excess of 410 kPa are to be experienced, it is advisable to fit a pressure regulator unit in order to maintain the accuracy of the control calibration. It is stressed that the filter unit cannot be used to produce medically pure gases.

The flow control of the ventilator is calibrated up to 1 l/sec. (60 l/min.) and it is therefore necessary to ensure that the drive gas source is capable of a free flow rate in excess of 80 l/min. at 410 kPa. Free flows of less than 80 l/min. may reduce the "To patient" flow from that indicated by the control.

5.2 Patient Valve Connection

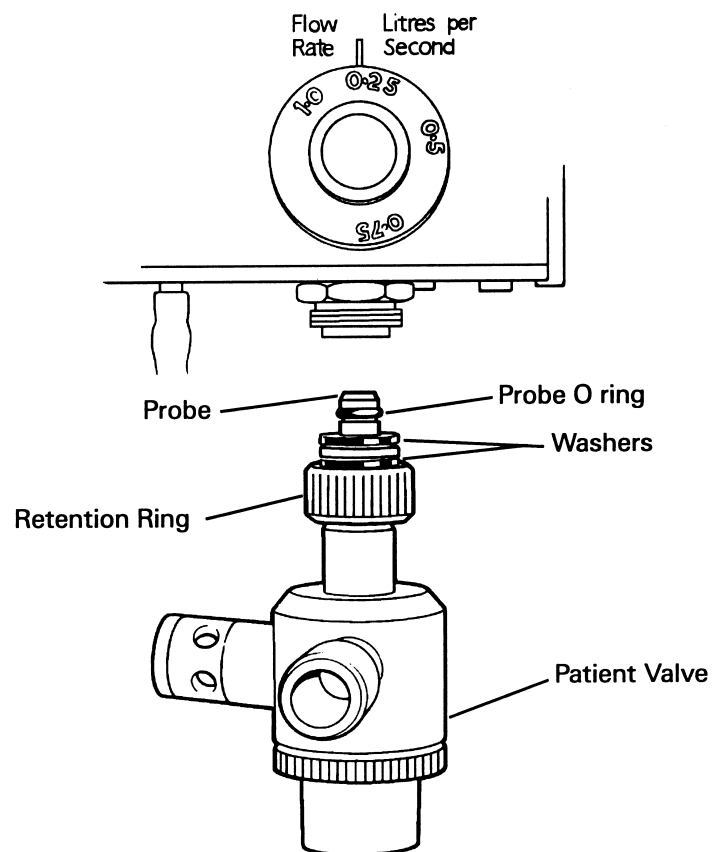


FIG. 5 **PATIENT VALVE CONNECTION**

The patient valve is connected by means of a probe and threaded retention ring. Before use the valve should be removed and the probe checked to ensure that the seal and washers are in position.

5.3 Dismantling the Patient Valve

Should the valve become blocked with any particulate matter or seized for any reason a simple procedure to dismantle can be adopted.

1. Remove the relief valve (1) by unscrewing from body (2).
2. Unscrew exhaust port (3) from main body, and remove piston and spring assembly (4) and two seals (5).
3. Detach the O ring (6) from the exhaust port.
4. Unscrew the probe (7) and remove the washers (8), the O ring (9), the sealing ring (10), and the retaining ring (11).

All parts can be individually washed.

To re-assemble the valve, repeat the above in reverse order. The design of the valve is such that incorrect assembly is impossible. However, it is important to check that the components have not been accidentally interchanged with Pneupac Resuscitator valves (Lat Para., Sec. 2.2.).

Function test the valve before clinical use – see Section 9.

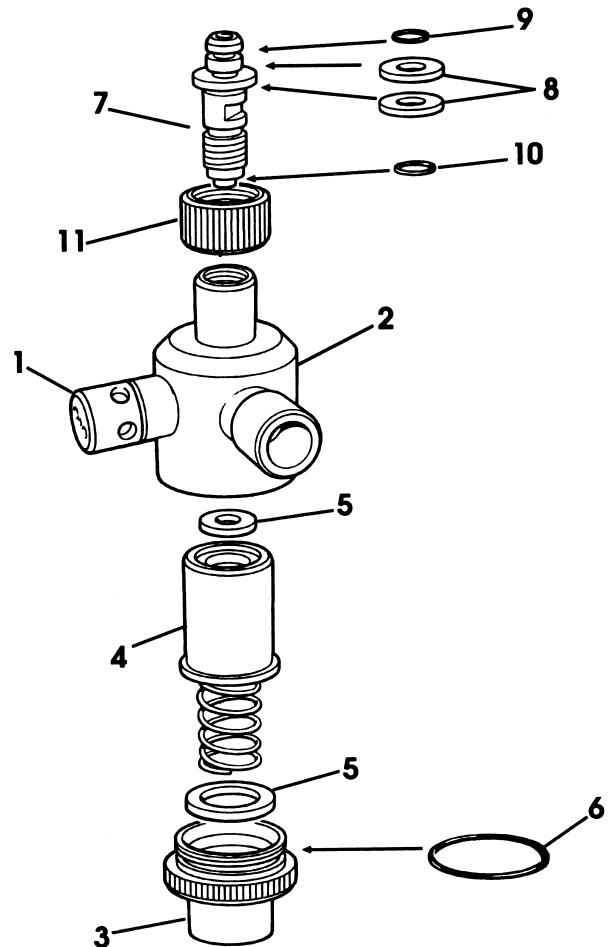


FIG. 6 DISMANTLING THE PATIENT VALVE

5.4 Setting of controls

The following sequence is recommended for basic setting of ventilator controls ⁽¹⁾. Firstly select the tidal volume appropriate to the patient's body weight and type of circuit to be used. The inspiratory time should then be selected and set on the control. Knowing the inspiratory time and tidal volume the inspiratory flow rate can be easily calculated and set on the ventilator control, e.g. 1.5 sec. inspiratory time and 0.5 l/sec. inspiratory flow rate will give a tidal volume of 1.5 sec. x 0.5 l/sec. = 0.75 l.

The expiratory time control is then set to determine frequency and I:E ratio. For example, inspiratory time 1 sec. expiratory time 3 sec. frequency = 15 bpm, I:E = 1.3.

- (1) Adams A.P. – A new ventilator for anaesthesia – Penlon AP200, (Anaesthesia.)
Note: AP200 was the prototype designation.

6. ANAESTHESIA APPLICATIONS

6.1 Co-Axial Circuit

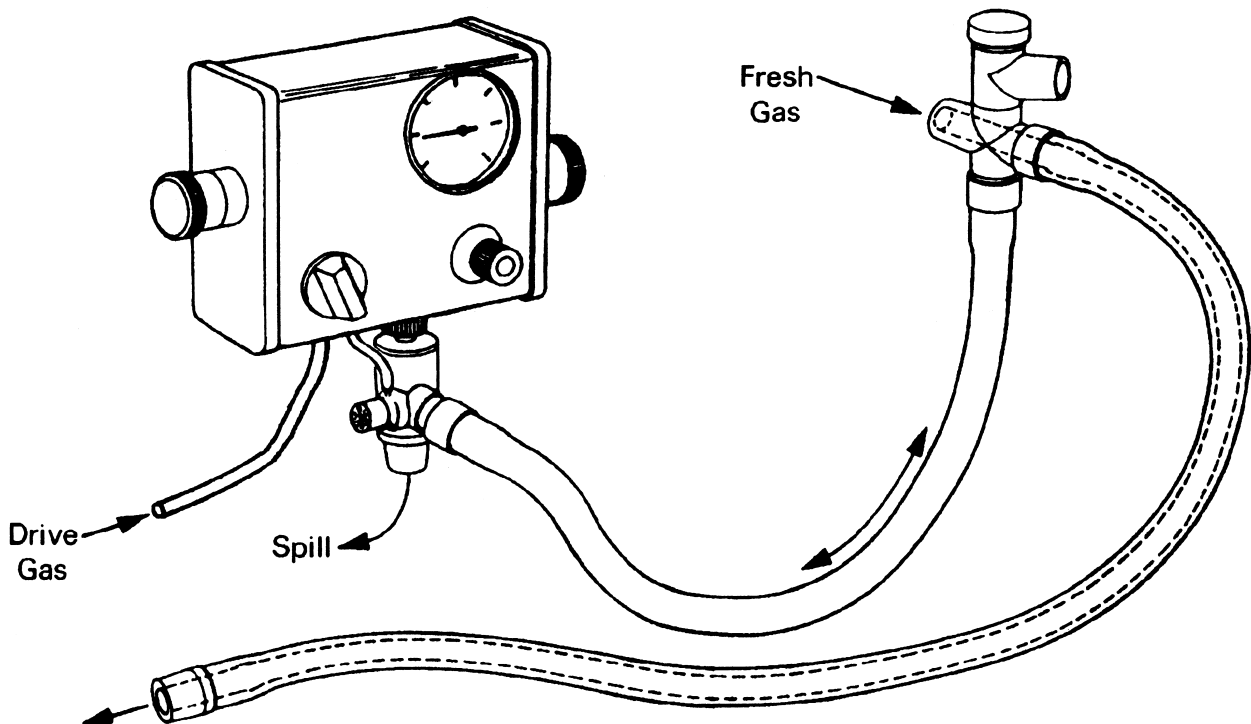


FIG. 7 CO-AXIAL CIRCUIT USE

The Penlon Co-axial Circuit (item 57050) is basically a Mapleson 'D' circuit and is normally used as a partial rebreathing system. It is suitable for both adult and paediatric use.

The Nuffield Ventilator is used to ventilate the circuit, thus displacing the anaesthetic gases into the patient.

Fig. 7 shows the system connected to the Nuffield, the reservoir hose connecting ventilator outlet to circuit bag mount connection. With this type of system it is essential that in order to prevent dilution of anaesthetic gases, the circuit compressible volume must be greater than the patient's tidal volume. To achieve this under normal clinical conditions a 1 metre reservoir tube is used to connect ventilator to circuit thus ensuring that the total circuit compressible volume is approximately 1200 ml.

During the inspiratory phase, the ventilator exhaust port is closed and gas from the ventilator is forced into the circuit. This gas in turn displaces the anaesthetic gases within the circuit into the patient. However, during inspiration the continuous fresh gas flow augments the patient's tidal volume. For example, at 20 bpm, I:E ratio of 1:2, the inspiratory time = 1 sec. If fresh gas flow = 6 l/min. (0.1 l/sec.) then during the 1 sec. inspiratory phase $1 \times 0.1 = 100$ ml will be added to the patient's tidal volume.

During expiration, expired gases from the patient's lungs are displaced back through the ventilator exhaust port whilst fresh gas builds up in the co-axial circuit, near to the patient, to be taken into the lungs during the next inspiratory phase.

Manual ventilation is achieved by disconnecting the ventilator and reconnecting the breathing bag to the co-axial circuit.

6.2 Expired Gas Pollution Control

As the patient's expired gas discharges from the exhaust port situated on the patient valve (or Newton Valve) of the ventilator, it is a simple matter to duct away these gases by connecting the exhaust port to a suitable pollution control system. Penlon provide a complete range of equipment for pollution control in operating theatres, etc., and information is available upon request.

Note that the inclusion of a British Standard type Air Break Unit, between the patient valve (or Newton Valve) exhaust port and the suction unit will overcome the possibility of excess suction.

6.3 Monitoring

Actual tidal volume and minute volume may be monitored by a spirometer situated at the patient connection only.

A respiratory pressure gauge is sited within the module to show breathing circuit pressure. This will not differ greatly from the airway pressure as the resistance of the circuit to the higher inspiratory flow rates is extremely low.

Summary of clinical adjustment of Nuffield Ventilator when used with Co-axial Circuit (ref. Henville J.D. & Adams A.P. (1976) *Anaesthesia*, 31, 247)

1. Oxygenation of the patient is assured primarily by the fresh gas flow selected, although suitable values of tidal and minute volume must also be employed.

The fresh gas flow should be within the range 70-100 ml/min/kg body weight with a minimum of 3 l/min. for small patients.

2. Tidal and minute volume ventilation are selected on the controls of the Nuffield Ventilator as described on page 18.
3. As mentioned on page 19, the fresh gas flow augments the ventilation above the values calculated from the setting of the controls. The table below can be used to determine the value of the additional ventilation, which added to the calculated value will give the true tidal volume.

In many cases, it may be preferred to check the tidal volume by measurement, as calculated values do not take into account the compliance of the breathing circuit, which may be significant at small tidal volumes.

Calculation of augmentation effect:

V_t = tidal volume (litres)

t_i = inspiratory time (sec.)

V^o = flow rate set on Nuffield Ventilator (l/sec.)

V^o_f = fresh gas rate expressed in l/sec. ($= \frac{1}{4} \times \text{l/min.}$)

$$\text{True } V_t = t_i V^o + t_i V^o_f$$

Values of $t_i V^o_f$ are given in the table overleaf. These may be added to $t_i V^o$ to obtain the value of V_t .

t_i	=	0.2	0.25	0.5	0.75	1.0	1.25	1.5	1.75	2.0
$V_o = 3$	l/sec:	.010	.012	.025	.038	.050	.062	.075	.087	.100
4	:	.013	.017	.033	.050	.067	.083	.100	.116	.133
5	:	.017	.021	.042	.062	.083	.104	.125	.146	.167
6	:	.020	.025	.050	.075	.100	.125	.150	.175	.200
7	:	.023	.029	.058	.087	.117	.146	.175	.204	.233
8	:	.027	.033	.067	.100	.133	.166	.200	.233	.267
9	:	.030	.038	.075	.112	.150	.187	.225	.262	.300
10	:	.033	.042	.083	.125	.167	.208	.250	.292	.333

7. RESUSCITATION APPLICATIONS

7.1 Emergency or Long-term Resuscitation

For emergency or long-term resuscitation the Nuffield Ventilator may be used by fitting a flexible hose between patient valve and module, and connecting directly to the patient using a suitable facemask. In this manner resuscitation may be achieved by driving the ventilator with air or oxygen from suitable pipeline or cylinder supplies.

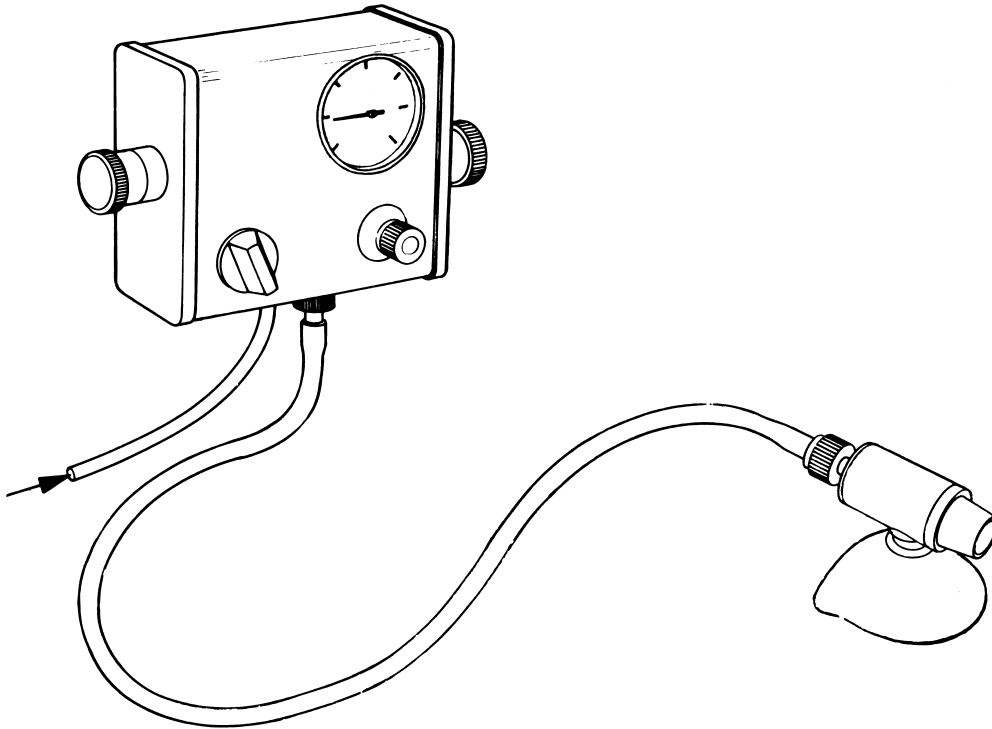


FIG. 8. EMERGENCY OR LONG-TERM RESUSCITATION

7.2 Use with Bronchoscope Injectors

Where automatic controlled ventilation is required during bronchoscopy the Nuffield Ventilator may be connected to a Sanders pattern injector by removing the patient valve and using a special connection hose.

The time controls operate normally under these circumstances but the tidal volume cannot be directly set by combining the inspiratory time and the flow rate settings. Ventilation must be judged clinically.

7.3 Co-axial Circuit for Intensive Care Use

The co-axial circuit (ref Section 6.1) may be used for intensive care ventilation by replacing the anaesthetic gas with suitable air/oxygen mixtures supplied from a flowmeter-controlled source. Humidification can be achieved using an artificial nose at the patient connection.

7.4 **Monitoring**

Actual tidal volume and minute volume may be monitored by a spirometer situated at the patient connection only.

Respiratory volume and minute volume may be monitored by a spirometer situated at the patient connection only.

A respiratory pressure gauge is sited within the module to show the breathing circuit pressure. This will not differ greatly from the airway pressure as the resistance of the circuit is less than 5 cm of water at a flow rate of 1 l/sec. (Ref. Draft ISO Standard for breathing machines for medical use.)

8. **NEWTON VALVE DESIGN AND APPLICATION FOR NEONATAL/PAEDIATRIC ANAESTHESIA**

8.1 **Introduction**

The Newton Valve has been designed to replace the standard patient valve in order to extend the range of the ventilator to include small infants, neonates and premature babies.

The Newton Valve converts the ventilator to a time-cycled pressure generator capable of delivering tidal volumes between 0.5 l/min and 18 l/min (0.008 – 0.30 l/sec.)

When ventilating at very small tidal volumes, a pressure generator such as the Nuffield Ventilator with the Newton Valve, is preferable to a volume pre-set device, since the actual tidal volume delivered is affected by the leak around the uncuffed paediatric endotracheal tube, the compliance of the anaesthetic circuit, and the rate of entry of the fresh gas at the T-piece.

WARNING 1 The use of the Newton valve is limited to patients with a bodyweight of less than 20 kg, for whom the Ayre's T-piece and Jackson-Rees bag would normally be considered appropriate. To prevent confusion, the valve outlet has a 15 mm female taper only. Larger children can be ventilated with the standard Nuffield 200 Ventilator.

WARNING 2 The tidal volume delivered to the patient cannot be calculated from the setting of the flow control on the ventilator since this merely indicates flow leaving the control module, and does not relate to the flow directed into the patient's lungs.

WARNING 3 The valve must not be used with a vacuum-scavenging device since this may affect the flow of gas across the orifice. Scavenging systems should comply with the Draft International Standard which limits negative pressure to 50 Pa (0.5 cm w.g.)

8.2 **Construction**

The principle of operation of the Newton Valve is that the gas flowing from the control module of the Nuffield Ventilator enters a chamber with two outlet ports. One is the connection for the anaesthetic circuit reservoir tubing, the other leads via an orifice to open air (or an anti-pollution system). See Fig 9.

The flow of gas from the ventilator control module during inspiration produces a back pressure at the orifice which is transmitted to the anaesthetic circuit via the reservoir tubing. The flow of gas can be adjusted between 0.25 l/sec. (15 l/min.) and 1.0 l/sec. (60 l/min.) by the flow control on the ventilator which accurately controls the inflation pressure.

The valve body has a connection for the manometer tube from the ventilator, so that the pressure can be measured, and a patient protection Pressure Relief Valve (PRV) set at 60 cm H₂O is also incorporated.

The expired gases leave the anaesthetic circuit through the same orifice in the valve which has been designed to offer minimal resistance to the much lower flow rates occurring during passive expiration (less than 5 cm H₂O at 15 l/min. peak expiratory flow, and less than 1 cm H₂O at 5 l/min.).

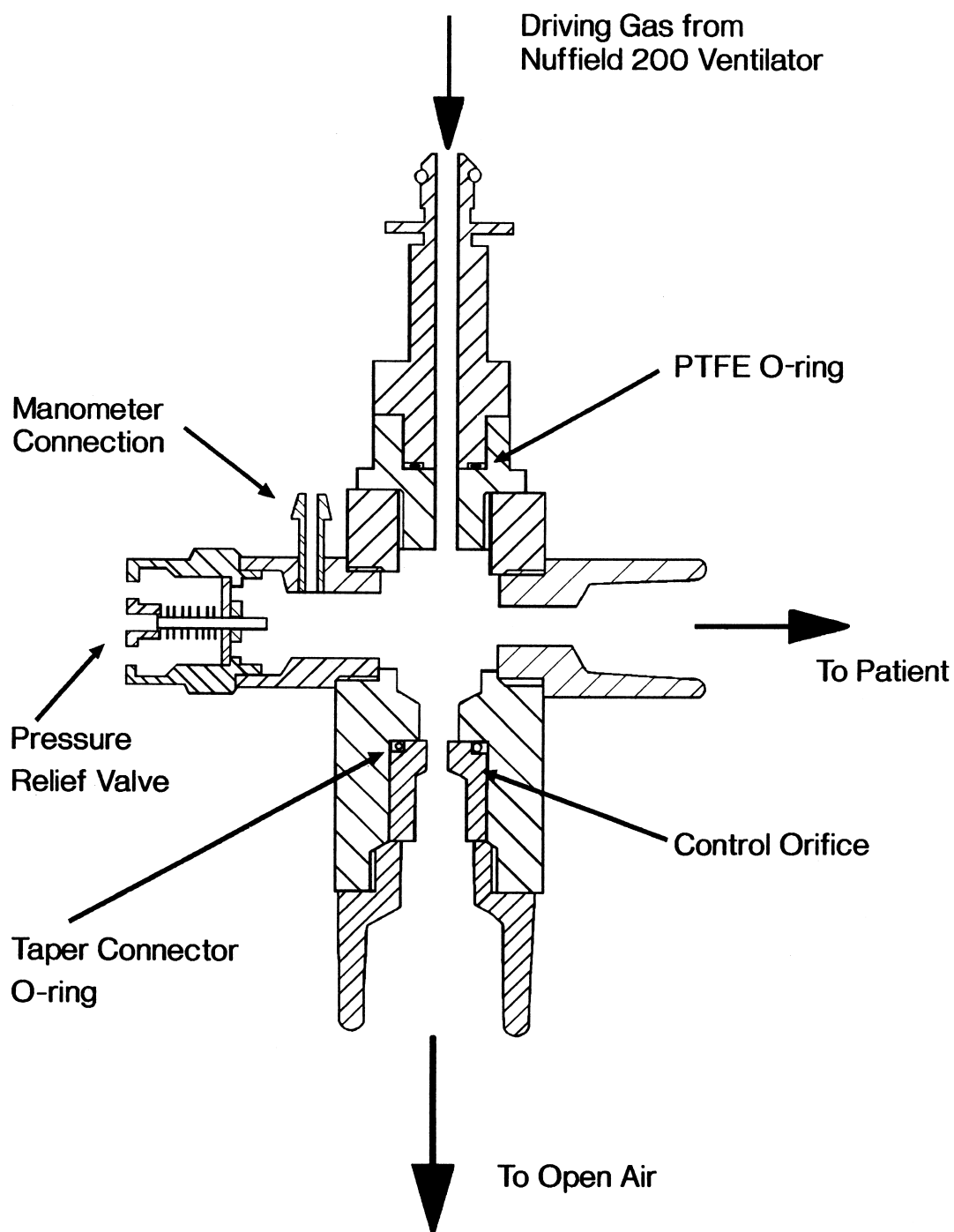


FIG. 9. NEWTON VALVE (SECTIONAL VIEW)

8.3 Installation

The Nuffield Ventilator is installed in the normal manner, with either air or oxygen as the driving gas. (This gas does not reach the patient).

The standard inflating valve is detached by unscrewing the union between ventilator and valve and detaching the manometer connection tube.

The Newton Valve is then attached to the ventilator by the union connection and the manometer connection tube. (See Fig. 9 and 10.)

The lightweight one-metre reservoir tube provided is connected by its 15 mm taper male connection to the outlet port of the Newton Valve, whilst its distal (female 15 mm taper) connection receives the Ayre's T-piece circuit, once the Jackson-Rees bag has been removed.

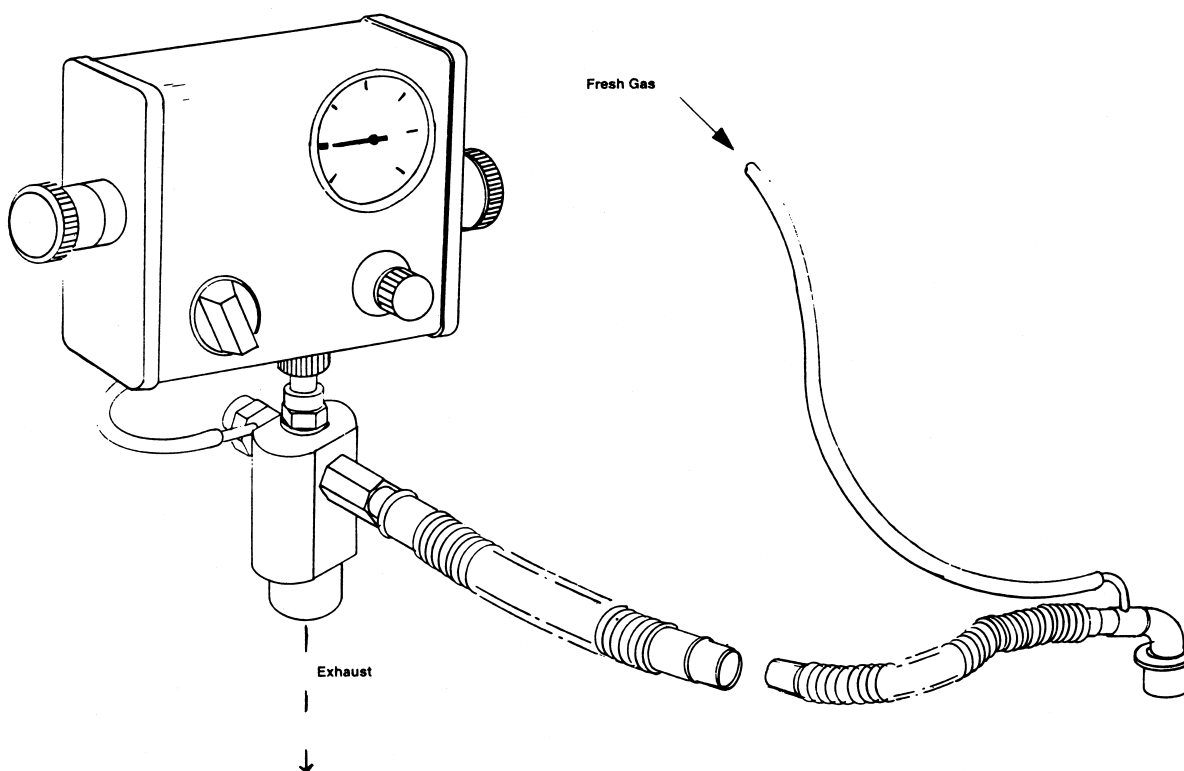


FIG. 10. NEWTON VALVE USE

The outlet port at the bottom of the Newton Valve has a 30 mm male taper allowing connection of an anti-pollution system, or positive end-expiratory pressure (PEEP) valve (such as the Ambu PEEP valve) if required.

8.4 Controls

The inspiratory and expiratory time controls of the ventilator are unaffected by the change of valve and can be used to set up the required breathing cycle. The fresh gas flow from the anaesthetic machine has little effect on the tidal volume delivered to the patient which is determined by the duration of inspiration, and the inflation pressure is set by adjusting the flow control on the ventilator. The fresh gas flow will, however, determine the patients $p\text{CO}_2$, when the minute volume of ventilation exceeds the fresh gas flow (as is common practice during hand ventilation with the Jackson-Rees bag).

Typical values for fresh gas flow are:–

A minimum recommended flow of 3 l/min. for neonates, up to 15 kg bodyweight (this necessitates a reduction in the ventilatory minute volume for neonates in order to avoid hypocapnoea).

A flow of 3 – 4.5 l/min. for patients from 15 – 20 kg bodyweight.

These values must be adjusted according to clinical conditions.

When the setting for the expiratory time is too short, the pressure shown on the manometer may fail to return to zero before the next inspiration occurs. If a zero end-expiratory pressure is required, the expiratory time should be lengthened. Alternatively, when a degree of PEEP is desired, a PEEP valve may be fitted to the expiratory port with little effect on the tidal volume delivered.

8.5 Cleaning and Disinfection

The Newton Valve should be detached from the ventilator, then treated by washing, chemical disinfectant or autoclaving at 136°C. There are no moving parts and it is not necessary to dismantle the valve itself for these processes.

The function of the PRV should always be checked after disinfection or autoclaving by setting a high flow on the ventilator control and occluding the patient port.

The reservoir hose assembly is not suitable for autoclaving and should be disinfected by chemical means.

8.6 Maintenance

The valve should be serviced with the ventilator at three-monthly intervals.

Servicing procedure:

Unscrew 30 mm taper connector (peg spanner required).

Lift out control orifice and O-seal.

Clean all components, taking care not to damage orifice, which is carefully calibrated during production.

Re-assemble components and tighten 30 mm taper connector in place.

Check seals on union connection to ventilator.

Check function of PRV.

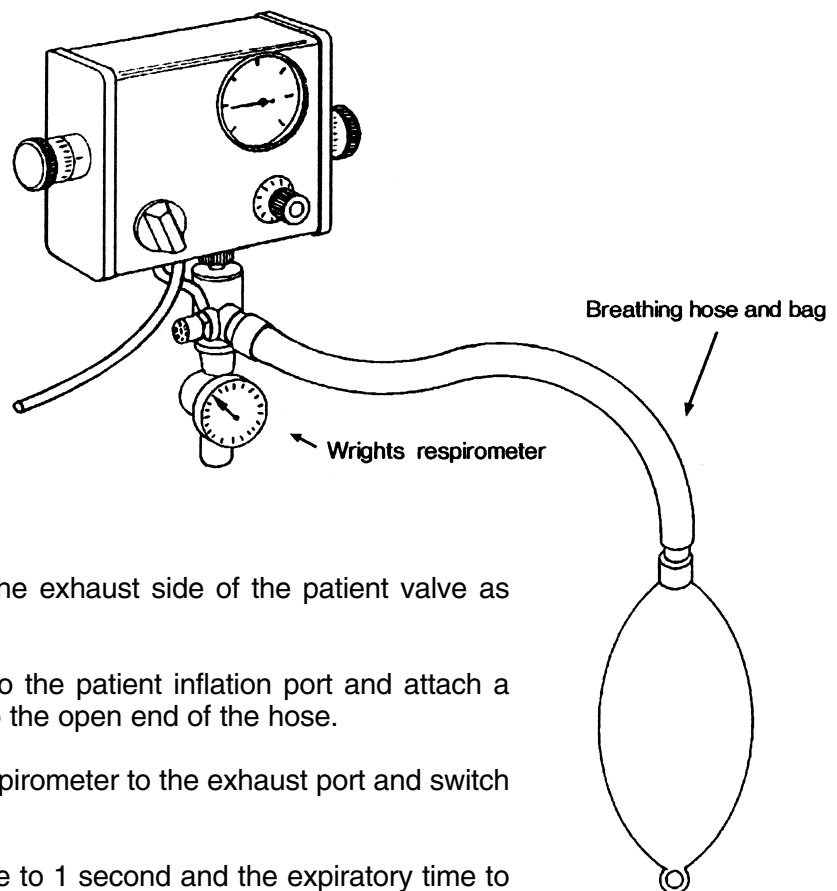
9. FUNCTION TESTING

These simple checks may be carried out by hospital staff and, if performed correctly, should eliminate problems which could arise from faulty assembly or damage to components. In addition, regular servicing by a Penlon trained engineer is essential to ensure long term reliability.

9.1. Patient Valve Functional Checks

Ensure that the O ring is correctly fitted to the probe and that the flat shock washers are fitted (see section 5.2). Fit valve to ventilator and switch on ventilator, observing correct movement of piston by looking through the valve exhaust port.

With ventilator operating, connect valve to manometer, occlude "to patient" connection and check that relief valve is functioning correctly and at the appropriate relief pressure.



Check the gas flow from the exhaust side of the patient valve as follows:

1. Fit a breathing hose to the patient inflation port and attach a 2 litre breathing bag to the open end of the hose.
2. Connect a Wright's respirometer to the exhaust port and switch on the ventilator.
3. Set the inspiratory time to 1 second and the expiratory time to 2 seconds.
4. Set the flow rate of 0.5 l/secs.
5. Verify that, after the bag is inflated, regular discharges of 0.5 litres (± 0.06 litres) of driving gas are made through the exhaust port to coincide with each expiratory phase.

9.2 **Control Module Check**

It is not recommended that the ventilator controls are regularly adjusted in any way. Provided the ventilator is operating smoothly, and the pneumatic circuit is functioning as in Section 2.1, the major components do not require any maintenance.

The calibration of the ventilator may be checked by timing its operation with a stop watch over several cycles, and checking the flow rate against a flow meter. The flow rate may also be checked by monitoring the tidal volume. Setting tolerances are shown in Section 3.

N.B. Ensure that the drive gas supply is oxygen at 410 kPa and is capable of a minimum free flow rate of 80 l/min.

9.3 **Routine Maintenance**

Routine maintenance work required for the Nuffield Ventilator should consist only of replacing rubber seals as and when necessary, and checking the calibration settings.

Any malfunction or failure of the control module should be investigated by a Penlon-trained engineer and where possible service exchange units will be used for major servicing.

10. **STERILIZATION**

The patient valve is the only unit that should be sterilized. Under no circumstances should the control module be sterilized other than wiping with a disinfectant.

The patient valve is removed by unscrewing the retention ring. If the valve is contaminated by blood, sputum, etc., it should be dismantled and washed thoroughly before autoclaving, see Section 5.3.

Suitable sterilization procedures are as follows:–

1. Autoclaving at 136°C.
2. Gas sterilization (e.g. ethylene oxide)
3. Low temperature steam
4. Boiling water
5. Chemical immersion

11. ORDERING INFORMATION

11.1	Accessories	57101	Drive gas hose – mini-Schraeder, 1 metre
		57102	Drive gas hose – Mk3 BOC O ₂ probe, 4 metre
		57103	Drive gas hose – DISS O ₂ , 1 metre
		57104	Drive gas hose – Mk3 BOC Air probe, 4 metre
		57108	Bronchoscope injector hose assembly for Nuffield 200
		57109	Resuscitation hose assembly for Nuffield 200
		57110	Patient valve for Nuffield 200
		57120	Universal clamp for Nuffield 200
		57121	Modura clamp for Nuffield 200
		57122	Medirail clamp for Nuffield 200
		57140	Newton valve complete with hose assembly in case
		57141	Newton valve only
		57142	Hose connector 15 mm male – 22 mm hose
		57143	Hose connector 15 mm female – 22 mm hose
		57144	Conductive breathing hose – 160 cm
		57145	Case and insert for Newton Valve
		57146	Ayre's Tee piece case insert only
		57050	Penlon Co-axial Circuit complete (I.S.O.)
		57150	Penlon Co-axial Circuit complete (B.S.)
112	Spare Parts (Patient Valve)	21745	– Shock washer
		21747	– Retention ring
		21748	– Outlet probe
		22020	– Pressure relief valve
		462110	– 150 mm Manometer hose
		0314	– 'O' ring
	Newton Valve	22020	Pressure relief valve
		0579	PTFE 'O' ring
		21792	Control orifice
		0226	'O' ring
		21745	Shock washer
		0314	'O' ring
		462110	150 mm Manometer hose

For more detailed spare parts listing, please see Service Manual NV282 SM, Catalogue No. 57138, (available to Penlon-trained engineers).

User's Notes



Penlon



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