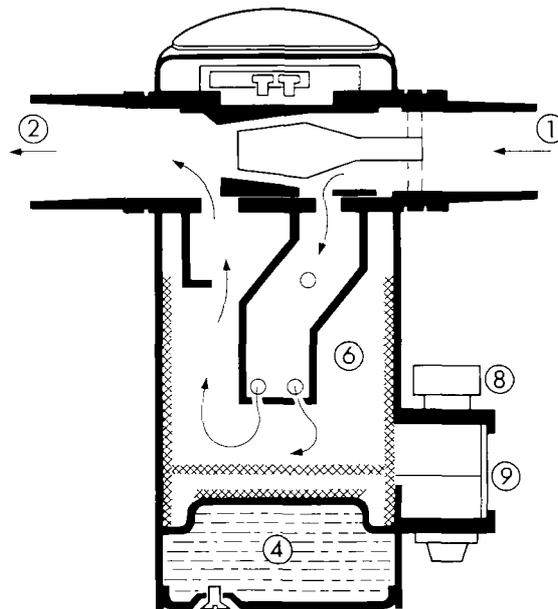


Vaporizers

Oxford miniature vaporizer (OMV)

This is a small vaporizer (Fig. 4.7) which can be used to administer anaesthetics. It works in the same way as the larger vaporizers, but does not have a built-in temperature compensation device. However, the base is filled with antifreeze to help stabilize the internal temperature. A number of different versions are available, each of which can be fitted with different scales for use with different anaesthetic agents.

Fig. 4.7. Oxford miniature vaporizer: (1) inlet port; (2) outlet port; (4) water jacket; (6) vaporizing chamber; (8) filling port for anaesthetic; (9) anaesthetic-level indicator.



The volatile anaesthetic liquids contain non-volatile substances such as thymol. These accumulate inside the vaporizer and will adversely affect performance, if present in excessive quantities. Removal of the deposits is therefore an essential part of the maintenance of vaporizers. Simple cleaning can be undertaken quite easily and requires no tools. It should be carried out as soon as any stiffness is noticed in the control pointer. However, major cleaning will require special tools and should only be necessary on rare occasions.

Simple cleaning procedure

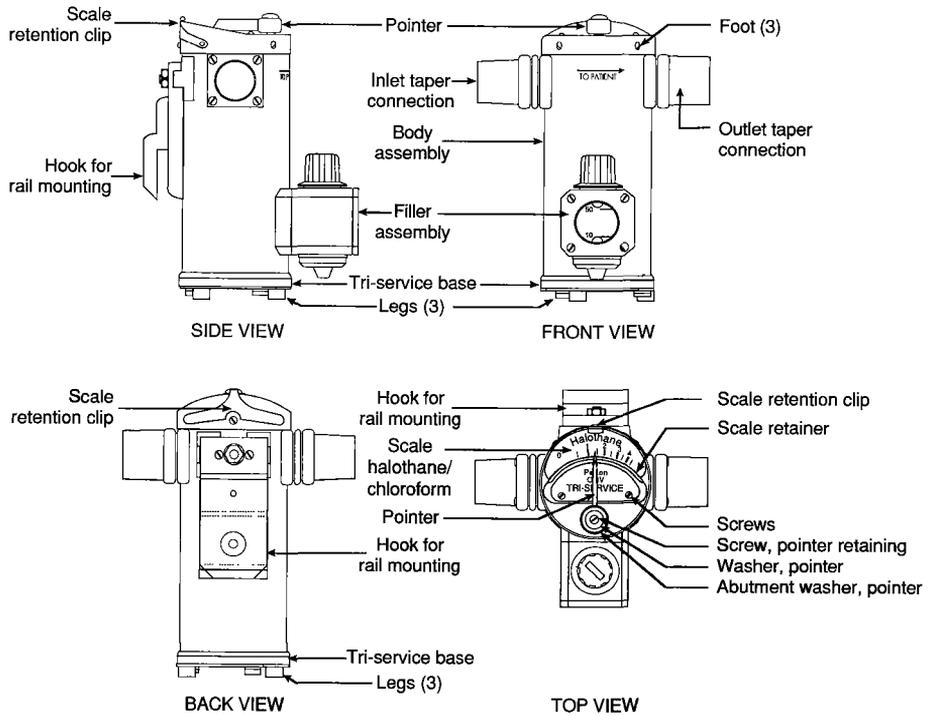
1. Put a rubber bung into the inlet and turn the vaporizer on to its side, with the outlet port pointing upwards.
2. Pour cleaning fluid (methanol or ether) into the outlet, while moving the pointer to and fro.
3. The vaporizer should be completely filled and allowed to stand for 5 minutes before emptying.
4. The vapour of the cleaning fluid that is left in the vaporizer should be completely removed by opening the control fully and blowing air through the vaporizer for 15–20 minutes with an inflating bellows.

Major cleaning procedure

If possible, refer to the manufacturer's service manual.

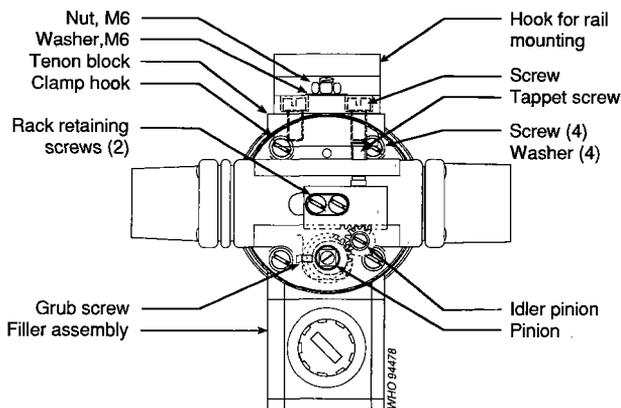
1. Remove the pointer by removing the screw and the washer. Lift off the pointer and abutment washer, and remove the scale (Fig. 4.8).

Fig. 4.8. Detail of the Oxford miniature vaporizer.



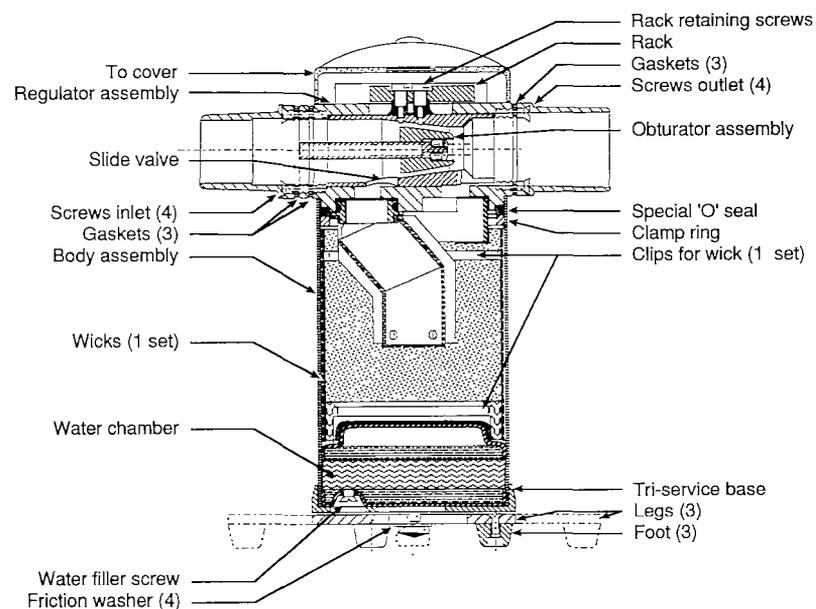
2. Take out the three screws from the lid, and lever the lid off the body. **Note:** These screws are rather short and have a fine thread; treat them very carefully, otherwise the thread will be stripped on the screw or on the vaporizer. Should this happen, it will have to be re-tapped, and a bigger screw fitted.
3. Remove the M6 nut and washer, and take off the "off-line" hook (Fig. 4.9). Remove the two screws, and take off the tenon block and clamp.

Fig. 4.9. Detail of the Oxford miniature vaporizer: top view (pointer and scale removed).



4. Remove the four screws and washers. Lift out the regulator assembly, O-seal, and clamp ring.
5. Part-fill the vaporizing chamber with cleaning liquid (as above). Shake gently to wet all parts of the wicks. Allow to soak for 2–3 minutes and shake it again; repeat this several times. Discard the liquid. Repeat the process until the discarded liquid appears clean. Invert the chamber and allow to dry completely.
6. If the indicator glass is still dirty after the above process, remove the four screws securing it, lift out the glass and wipe clean. Replace the glass, ensuring that the seals and centring ring are replaced in the correct position.
7. If corrosion is present on the wick, e.g., rusty patches, reassemble the vaporizer and return it to the manufacturer for replacement of the wicks.
8. Dismantle the regulator assembly:
 - Remove the inlet and outlet cones (4 screws each), gaskets, and obturator assembly (Fig. 4.10).

Fig. 4.10. Detail of the Oxford miniature vaporizer: cut view, side.



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- Remove the two screws securing the rack. Lift off the rack and spacers. Note that the plastic sleeves inside the spacers must be retained. Also note the relative position of the ports¹ and the direction of the cone of the slider.
- Remove the slide-valve by pushing from the outlet end of the regulator housing. If it is stiff, use a wooden or plastic drift (stick) to push it out. Do not use metal, as this will damage the machined surfaces.
- Soaking the assembly in ether or alcohol will usually dissolve the deposits that are causing the stiffness.
- Wash the slide-valve and regulator housing in cleaning fluid and dry with a clean cloth, paying particular attention to the sliding surfaces. **Never** clean these with abrasive compounds. Metal polish may be used to remove stubborn dirt after first carefully removing the residues and before re-assembly.

¹ Modern versions have markings on the ports so that they can be realigned in the correct position. Older versions may not have these markings, so, before taking the assembly apart, scratch a line with a screwdriver over the connecting parts.

- Refit slide-valve to housing.
 - **Do not** use any oil or grease. Check for smooth motion from one end of the housing to the other.
 - Check the location of ports and the direction of the cone, and reassemble the rack with spacers and screws, lining up the marked tooth rack between the two marked teeth on the idler pinion, and, at the same time, the marked teeth on the idler and the pointer pinion.
9. Backlash can develop between the rack and idler, or between the idler and pinion.
- A tappet screw is provided to adjust the engagement of the former.
 - The pinion is mounted in an eccentric bush, and engagement with the idler is adjusted by slackening the lock screw, rotating the eccentric bush, using a 3-mm bar in the hole provided, until the engagement is correct, and then tightening the lock screw.
10. Reassemble the reducing valve assembly body
- The special PTFE¹-coated O-ring that seals the assembly must be examined for damage, and repeated if necessary.
 - Separate the clamp ring and regulator housing by removing the four screws and washers.
 - Insert the clamp ring into the body with the four screw-holes at 45 degrees to the reducing-valve housing, in plan.
 - Immerse the O-ring in warm water (40–50 °C) for a few minutes, to soften it.
 - Place the O-ring on top of the clamp ring.
 - Insert the regulator housing assembly using the 3-mm tommy bar to line up the screw holes in the clamp ring and regulator housing. Insert the draw-screws into two diagonally opposite holes to draw the clamp ring into the body (hand-tight only).
 - Insert two screws and washers, remove draw-screws, and insert the two remaining screws and washers.
 - Tighten all four screws evenly and fully, making sure the regulator is pressed home fully into the body without gaps beneath inlet and outlet square section.
11. Examine the obturator assembly to ensure that the adjustment screws are sealed. If the seal is broken it is advisable to return the unit to the manufacturer. Assemble the gaskets, obturator assembly, and inlet connector with four screws to the reducing-valve housing. Check that the obturator is concentric with the slide-valve. Assemble the gasket and outlet connector to the regulator housing.
12. Test the main body seal for leaks:
- With the slide-valve open, block the outlet connector and apply pressure to approximately 180 mmHg through the inlet connector.
 - Run a small quantity of cleaning fluid (ether or alcohol) into the joints between the regulator assembly and the body.
 - Check for bubbles.
 - Tighten screws or replace O-ring, if necessary, to obtain a leak-free joint.
 - Tip out any surplus liquid, and allow the machine to dry completely.
13. Reassemble the tenon block, clamp, off-line mounting block, lid, and pointer (reverse of dismantling instructions). Do not fit the scale at this stage.

¹Polytetrafluoroethylene.

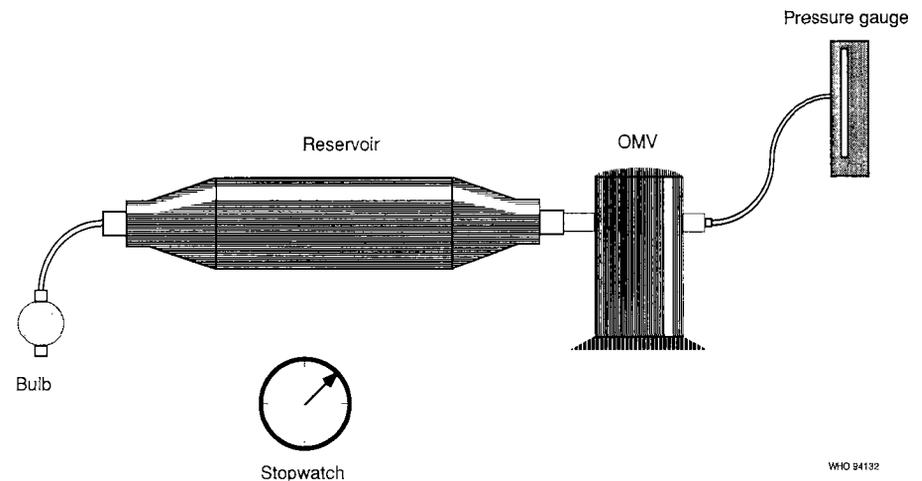
Check pointer setting

Do this by inserting a setting gauge, OMV 1, through the outlet side into the valve port, with the pointer between 50 and 60 on the engraved scale on the lid. Move the pointer towards the left until no further movement is possible. The pointer should then indicate 35 on the engraved scale. A positional error of ± 1 mm is acceptable. If the gear train has been wrongly assembled, an error of 7.5 degrees per tooth will be introduced, so that the errors are easy to detect. Remove the setting gauge, assemble the outlet connector and gasket with four screws, and fit the scale back in place.

Testing for leaks

This procedure should be carried out if the unit is reported to be giving low concentrations or is using excessive quantities of halothane or trichloroethylene. Connect the vaporizer to a reservoir, pressure gauge, and air source, as shown in Fig. 4.11. Pump air into the system until a pressure reading of approximately 210 mmHg (28 kPa) is reached. Clamp off the air-supply line with a pair of forceps. The pressure in the system will fall slowly; use a stopwatch to record the time taken for it to fall from 200 mmHg to 190 mmHg.

Fig. 4.11. Leak test layout.



Carry out the test with:

- The control pointer in the OFF position to test the connectors and the top of the regulator housing. Acceptable value: 30 seconds or more.
- The control pointer in the "3.5" position to test the vapour chamber joints. Acceptable value: 30 seconds or more.
- The control pointer in the OFF position and the filler held open to test the vapour seals. Acceptable value: 15 seconds or more.

If the vaporizer does not pass this test, look for the position of the leak by brushing soap solution around the suspect joints while maintaining the internal pressure. Bubbles will form at the leak site. Do not apply soap solution to the opening around the rack, where it could enter the slide valve (once it dries, it will cause the slider to stick).

Note: There is always a certain amount of leakage from the slide-valve but this can be ignored if the test figures above can be obtained.

Specific repairs

Fitting a new level-indicator glass

Remove the four screws, take off the retainer, the old glass, seals, and centring ring. When fitting a new glass, always use new seals. Glasses vary a little in thickness. Three seals are provided in the spare-parts kit, and sufficient seals should be used to obtain good compression on the glass when the retainer is screwed back into place. Test the unit for leaks after fitting a new level-indicator glass.

Fitting a new drain seal

1. Remove the drain screw.
2. Use a pin spanner to unscrew the old drain-seal assembly from the filler block.
3. Discard the old assembly and seal.
4. Fit a new assembly and seal.
5. Tighten securely.
6. Test for leaks.

Fitting a new back seal

1. If a leak develops between the filler block and body, remove the retaining level-indicator glass.
2. With a screwdriver, lever out the engraved back plate of the level indicator; this will expose the heads of two socket-head screws.
3. If tightening does not cure the leak, remove the screws, lift off the filler block and fit a new seal between the block and the body.
4. Reassemble all parts and test for leaks.

Replacing a folding leg (where fitted)

Remove the screw securing the leg to the base, and fit a new leg and new friction washer. The legs are made of malleable material and will withstand flattening with a soft-faced mallet.

To tighten a loose leg (where fitted)

Remove the screw securing the leg to the base, and replace the friction washer. Reassemble.

Replacing the complete base

The complete base assembly, with its feet, is fixed to the body using adhesive. If this joint should be broken as the result of a fall, a suitable adhesive should be used to refix the base. Clean off the old adhesive before refixing, and ensure that the recess in the base is aligned with the water-filling screw.

Other repairs

Faults requiring the instrument to be returned to the manufacturer or agent:

- broken pointer,
- corroded wicks,
- broken seal on obturator.

The vaporizer should be recalibrated every two years by the manufacturer or agent.

Equipment required for servicing

Leak testing

A source of compressed air, at about 200 mmHg (26 kPa). In the absence of a mechanical pump, this may be provided by a blood pressure machine, a hand bulb, or an Oxford inflating bellows.

Rubber bungs to fit the inlet and outlet of the vaporizer, one with a 6-mm tube through it.

A reservoir of capacity 4 litres capable of withstanding a pressure of 200 mmHg (26 kPa).

A pressure gauge to read to 200 mmHg (26 kPa).

Liquid soap solution and a small brush.

Ether or methylated spirit.

A stopwatch.

A pair of clamping forceps.

Rubber or plastic tubing to fit a 6-mm tube.

General servicing equipment (Fig. 4.12)

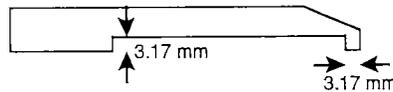
Setting gauge.

Drain plug key (spanner).

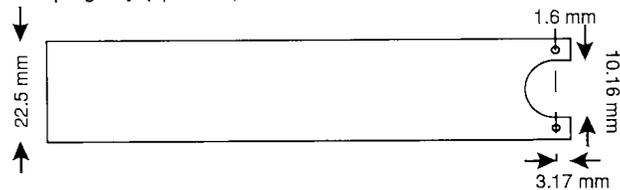
Draw screws.

Fig. 4.12. General servicing equipment.

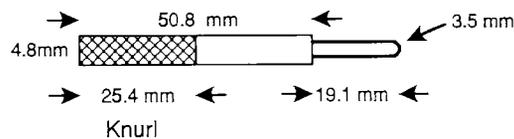
Setting gauge



Drain plug key (spanner)



Draw screw



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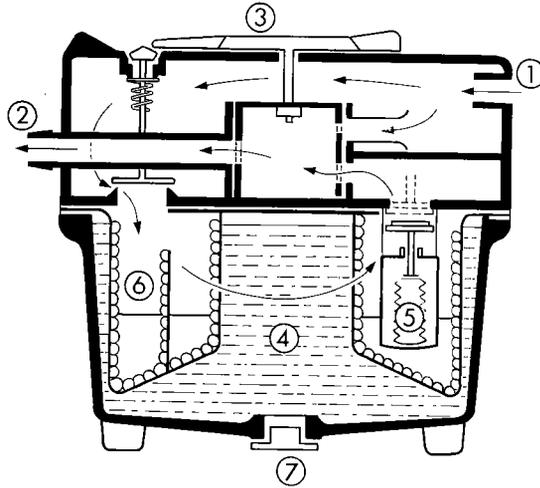
If the manufacturer supplies instructions giving reasons and situations when the equipment should be returned to them or their agent, these should be complied with wherever possible.

Epstein-Macintosh-Oxford (EMO)

The Epstein-Macintosh-Oxford (EMO) (Fig. 4.13) is an anaesthetic vaporizer with low internal resistance, for use with ether and air. It has a water-jacket, which helps

to keep the internal temperature constant, and a built-in temperature-compensating valve. The EMO has only two moving parts, the concentration rotor and the temperature compensator. These are set in the factory and should not be altered, except in an emergency, and then only after reading the service manual.

Fig. 4.13. EMO vaporizer: (1) inlet port; (2) outlet port; (3) concentration control; (4) water jacket; (5) thermocompensator valve; (6) vaporizing chamber; (7) filling port for water.

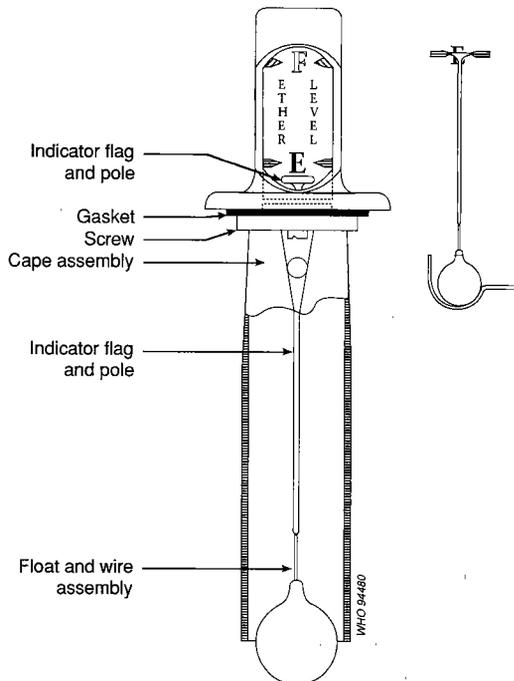


Some simple checks

Level indicator (Fig. 4.14)

With the ether compartment empty, slowly invert the vaporizer and check that the indicator moves freely, falling to the FULL position, and returning to the EMPTY position when the vaporizer is once again upright. When refilling, check that the quantity of ether used complies with the figures given in the instruction book.

Fig. 4.14. EMO: level indicator.



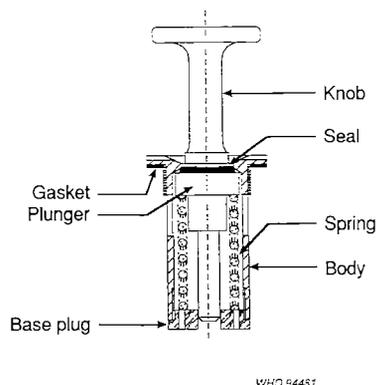
Closing mechanism

Turn the concentration control to the transit position, and connect the outlet of an Oxford inflating bellows, or other ventilating equipment, to the inlet of the EMO. Block the outlet of the EMO, apply gentle pressure to the bellows unit and open the ether filling port. There should be no escape of air through the filling port or through the top of the closing mechanism.

Filling port (Fig. 4.15)

With the bellows still connected to the inlet of the EMO and the outlet blocked, open the control knob to 10, close the filling port, and apply gentle pressure to the bellows; there should be no leakage through the filling port.

Fig. 4.15. EMO: filler unit.



Safety release valve

The safety release valve is combined in the closing mechanism unit. With the control knob set at 2, and with an Oxford bellows connected in the normal position on the outlet of the EMO, block the inlet and check that when the bellows is operated the safety valve operates, drawing air in through the valve.

Temperature compensating unit

The position of the temperature compensating indicator will show whether the unit is in satisfactory working order. The indicator consists of a rod with a black and red band, and a metal top. At 20–25 °C, the metal top and black band should be visible. At temperatures above 32 °C, the red band will begin to show. If only the metal can be seen at 20–25 °C, the compensating unit is faulty and should be replaced.

Water compartment

If the water used to fill the water compartment is thought to contain high concentrations of salts or chlorine, it is advisable to empty and refill the compartment from time to time.

Cleaning and sterilizing

Antiseptic solutions should not be used for cleaning the inhaler. The exterior may be cleaned by wiping with a cloth dampened in ether. Sterilizing is not normally necessary as the inhaler is used on open circuit, and protected from contamination by non-return valves. If special circumstances make it necessary to sterilize the

instrument, the only suitable method is by the use of ethylene dioxide gas. Excessive heat, such as during boiling or autoclaving, would damage the inhaler.

Fault-finding and rectification

In the event of difficulties in service read the manufacturer's instruction manual carefully. The following notes provide sufficient information for the user to obtain the best possible service from the EMO. It must be stressed that only pure ether should be used in the ether EMO; impurities may cause serious corrosion.

The causes of some of the commoner faults are listed in Table 4.1.

Table 4.1. Common faults with the EMO vaporizer

Fault	Cause	Rectification by user
Concentration control seized	Rotor seized	Return EMO to service engineer or agent
Ether escaping, although control is in "closed for transit" position	Broken level-indicator glass	Replace level-indicator unit
	Broken indicator glass on temperature compensating unit	Replace temperature compensating unit
	Closing mechanism not shutting	Adjust or replace closing-mechanism unit
Concentrations appear to be higher than normal initially, but drop rapidly during use	Temperature compensator not operating	Check the temperature compensating unit and replace if necessary
	Filling port left open	Close filling port
Concentrations appear to be lower than normal	Leak in circuit	Find and rectify
	Relief valve on closing mechanism stuck open	Check the safety release valve Replace closing mechanism unit, if necessary
	Overfilled with ether so that vaporizing surface area is too small	Pour out excess ether and check level-indicator.
	Temperature compensator not operating	Check the temperature compensating unit; if it is suspect replace it
Level indicator fails to rise when ether is added, but moves freely when inhaler is inverted	Broken float	Replace level-indicator unit.
Level indicator sticks at any point and will not move when inhaler is inverted	Float caught by frayed wick	Remove unit, cut away frayed ends of wicks with scissors.
	Caught by collapsed ether compartment, owing to gas build-up in water jacket due to use of impure water.	Return to makers or agent for servicing

Replace defective parts in all cases. Spare parts are readily available from the manufacturer or from the principal agents, some on a service/exchange basis. This arrangement means that the defective part is returned to the firm, and a new or reconditioned one sent in exchange. When ordering spare parts, the serial number of the inhaler should be given, and the defective part returned with the order.

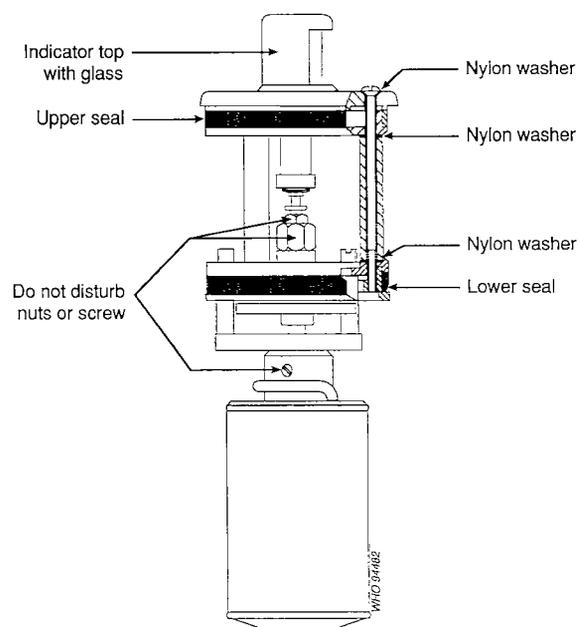
Fitting a new glass float

1. The wire on the glass float is crimped into a tubular form. To release the old wire, squeeze the tube across the direction of crimping, and pull the wire out with a straight pull.
2. Insert the wire on the new float, and crimp the tube lightly with a pair of pliers.
3. Fit the level-indicator assembly into the empty EMO inhaler, and check the position of the indicator when the float is resting on the bottom of the ether chamber. Adjust, so that the indicator is level with the two arrows on either side of 'E', by pulling or pushing the float as required.
4. When the position is satisfactory, crimp the tube in a second place more heavily to secure the float wire.

Temperature compensating unit (Fig. 4.16)

When ordering a replacement unit, specify the part number and the serial number of the inhaler marked on a plate on the back of the body.

Fig. 4.16. EMO: temperature compensating unit.



The unit is retained in the inhaler by three screws which expand rubber sealing sleeves when tightened. To remove the old unit:

1. Slacken all the screws by 3–4 turns.
2. Tap the heads of the screws down flush, using a plastic or wooden block.
3. Grip the top of the unit and twist or wriggle it slightly to break the grip of the rubber seals. You should then be able to lift out the unit.

It may be necessary to repeat steps 1 and 2 if the inhaler has been in use for some time. Do not remove the screws completely, as parts may be lost inside the inhaler. If the screws fall into the inhaler, they may be retrieved by tipping the machine up.

To fit a new unit:

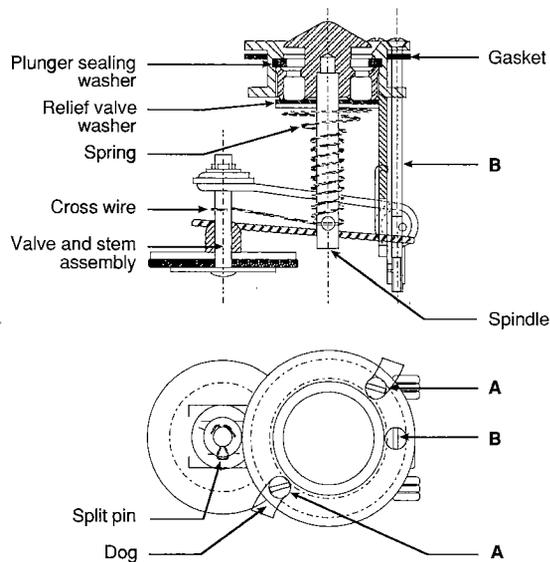
1. Make sure that the well in the inhaler body is clean. Slacken the three screws, and slide the unit into the inhaler body.
2. Check that the top plate fits correctly to the inhaler, without gaps, and tighten the screws.

Note: If the unit is removed for any reason, it is desirable to fit new rubber seals before it is refitted into the inhaler. These are available as: lower sealing ring, upper sealing ring, and nylon washers for screw heads. EMO inhalers made after January 1986 have O-ring seals that replace the lower and upper sealing rings.

Closing mechanism (Fig. 4.17)

The closing mechanism unit is retained in the inhaler by two “dogs” operated by screws (marked A in Fig. 4.17). To release the unit, unscrew these by 2 or 3 turns only, and tap the top of the unit lightly with a piece of wood or plastic to break the grip of the sealing washer. A further turn on each screw should then release the dogs and the complete unit can be lifted out.

Fig. 4.17. EMO: closing mechanism.



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To reattach the closing mechanism to the inhaler, make sure that the dogs are turned fully in, and insert the unit into its seating, checking that the tongue provided on the inhaler fits into the slot in the body of the closing mechanism.

Tighten the two screws by one turn, lift the unit to check that both dogs are engaged and then tighten the screws fully.

To fit a new valve assembly:

1. Remove the split pin and small washer. Discard the split pin.
2. Using fine pliers, disengage the spring wire from the hole in the valve stem.
3. Remove the whole valve-stem assembly and fit a new unit by reversing the procedure. Use a new split pin.

To fit a new relief washer:

1. Pull down the spring, and hold the spindle inside it.
2. By pressing the spindle away from the closing-mechanism body, disengage the top end. The washer can then readily be replaced.

To fit a new body sealing washer:

1. Remove the two screws, 'A', and dogs and adjusting screw, 'B'.
2. Remove the old washer by stretching it over the body. Fit the new washer in the same way.

3. Reassemble dogs and screws 'A' and 'B'.
4. Check against Fig. 4.17 for the correct position. The dogs should be a tight fit on screws 'A'.
5. Readjust unit as described below.

Adjustment of unit fitted to inhaler:

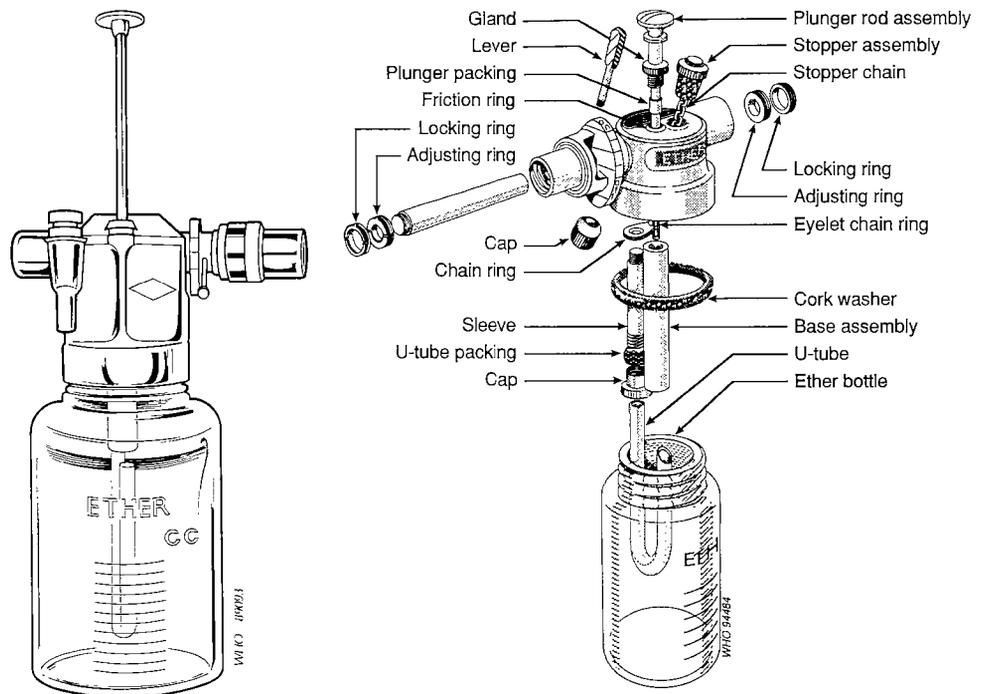
1. After fitting, a new unit may need to be adjusted to ensure correct seating of the valve. Screw 'B' is provided for this purpose. Turning this screw clockwise will increase the closing pressure on the valve.
2. The screw should be adjusted so that the control pointer can operate the closing mechanism without undue force, and the valve closes soundly when checked as described on page 87.

As already stated, the rotor is correctly adjusted before the machine leaves the factory, and should not be interfered with in any way.

Boyle's ether vaporizer

Boyle's ether vaporizer operates through a controllable bypass, which directs the required proportion of anaesthetic gas (0–100%) through a U-tube, to emerge over the liquid ether contained in the glass jar. Vapour concentration may be increased to a maximum by depressing the cowl plunger, thus causing the gas to bubble through the liquid (Fig. 4.18).

Fig. 4.18. Boyle's ether vaporizer.



Servicing

Boyle's ether vaporizer should be serviced as follows:

1. Check that all the apparatus gas supplies are turned off.
2. Remove the vaporizer from the back-bar assembly.
3. Remove the locking nut and adjustment rings from the gas-inlet side of the vaporizer body.

4. Remove the drum-actuating lever and withdraw the drum. (If the drum is seized or cannot readily be withdrawn, remove the locking ring from the gas outlet and turn the adjusting ring in a clockwise direction to force the drum out.)
5. Examine the drum for signs of scoring or corrosion; remove the old grease and apply a film of a suitable grease.
6. Remove the drum-grease injector cap and clean all the old grease from the body assembly.
7. Unscrew the plunger-control-gland packing nut, probe out the packing cotton and regrease it. Replace the cotton and the gland-packing nut.
8. Insert the drum and refit the actuating lever.
9. With the outlet-adjusting ring removed, screw in the inlet adjusting ring, while moving the actuating lever to and fro, until an increase in resistance to lever movement is felt. (**Do not** overtighten the ring to the point of drum seizure, as this will force out all the grease.)
10. Without moving the adjusting ring, fit and tighten the inlet locking ring.
11. Screw in the outlet adjusting ring until it just touches the drum, then back off one-eighth of a turn; fit and tighten the locking ring.
12. Check the drum for freedom of operation.
13. Fill the grease-injector cap with grease and screw in to the grease point.
14. Examine the glass bottle for dirt and damage; replace as necessary.
15. Examine the U-tube and cowl for dirt and damage, and for security of attachment.
16. Examine the bottle-sealing washer for serviceability; replace as necessary.
17. Examine the cork stopper for serviceability and security of attachment to the retaining chain.
18. Refit the vaporizer into the back-bar unit assembly.
19. Using a continuity test-set, or multimeter, check that there is electrical continuity between the drum-actuating lever, the cowl-operating plunger, and the vaporizer body.
20. Test the back-bar for leaks. See p. 94 for the back-bar tests.

Testing anaesthetic machines, ventilators and related equipment

Anaesthetic machines and ventilators should be tested in the room or area where the equipment is situated, if at all possible. Service personnel must wear accepted operating-room clothing in the surgical areas.

Contact the person responsible for operating-room equipment regarding the movement or servicing of any such equipment.

Anaesthetic machines

Tools and materials required

Normal service tools
 Silicone grease
 Light oil¹
 Service manuals
 Watch with a second-hand
 Spare parts

¹ Do not use ordinary oil (such as motor oil) to lubricate any parts that come into contact with oxygen.