AN AUTOCLAVABLE VENTILATION FAILURE ALARM

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SUMMARY

A small ventilation failure alarm which can be used with all types of lung ventilator is described. The entire patient circuit can be removed and autoclaved easily. Activation of the unit is by a removable key, a mains failure warning is provided, and the alarm may be muted during aspiration of secretions from the tracheobronchial tree.

Most hazards during positive pressure ventilation fall into one of the following categories:

(1) Disconnection of ventilator from patient or major leak developing in the patient circuit.
(2) Obstruction in the patient's airway or patient circuit.
(3) Disconnection of the ventilator from electrical supply or failure of electrical supply.
(4) Failure of driving gas supply.

For the detection of these hazardous situations, a pressure-operated alarm system has been developed by Cape Engineering Ltd, with our assistance, and assessed in this Department.

DESIGN FEATURES

The alarm consists of a pressure connection attached to a monitor unit by a length of plastic tubing. The pressure connection consists of a "T" adaptor, which fits into the inspiratory or expiratory limbs of a ventilator circuit, bearing a juxtaposed male and female taper to BS.3849. The side-arm connects with a length of plastic (polyvinylchloride) tubing (internal diameter 0.157 cm) to a rigid capsule, one side of which has a recessed flexible polytetrafluoroethylene (PTFE) diaphragm which is 0.125 mm thick. The capsule is attached to the monitor unit by two knurled captive screws which allow the capsule to be removed from the monitor unit easily (fig. 1). The capsule, plastic tubing and "T" adaptor can be autoclaved.

The monitor unit is housed in a metal case (14.3×22×6 cm; weight 1.6 kg), which contains an electromechanical transducer, the electronic circuits and the alarm tone generator. The top of the unit bears the connection to the autoclavable capsule, the warning lights for high and low pressures, the high and low pressure range adjustment screws, a key-operated on/off switch, an audible alarm...
VENTILATION FAILURE ALARM

Fig. 2. Ventilation failure alarm.

muting switch, and mains on and off warning lights (fig. 2).

When in the operating position, the flexible diaphragm is in contact with a spring-loaded brass pin which in turn acts on a metal contact blade. The blade is deflected by pressure variations transmitted via the flexible diaphragm in the removable capsule, and the deflection is directly proportional to the pressure applied. At rest, the contact blade rests on an adjustable conductor which is linked electronically to the low-pressure alarm circuit. Deflection of the contact blade by pressures in the patient circuit brings the blade into contact with a second adjustable conductor which is linked to the high-pressure alarm circuit. The circuit is arranged so that only a low current (100 microamperes) is switched by the contact blades.

The electronic circuit for the low-pressure alarm consists of a timing circuit which delays a “low alarm” for 15 sec after the contact blade touches the low-pressure conductor, so that the low alarm will operate only if there is more than a 15-sec delay in pressurization of the patient circuit. In series with the timing circuit, is an audible alarm muting circuit, operated from a push-button on the top surface of the unit, which will interrupt the low alarm audible warning for 90 sec. This allows an adequate period of freedom from audible warning when the pressure in the patient circuit is reduced, for example during aspiration of secretions from the tracheobronchial tree.

The electronic circuit for the high pressure alarm is linked directly to the high pressure warning light and audible alarm. The mains supply to the unit also supplies power to a battery charger which maintains a battery (Ever Ready type NCB9—rechargeable dry cell). If the mains supply fails, a detector powered by the battery operates the mains-off light and the audible alarm.

ASSESSMENT

The device was assessed over a period of 240 hr of use in an intensive therapy unit and in operating theatres. In all cases the device was found to be easy to set up and could conveniently be placed at the bedhead, on a ventilator or on an anaesthetic
trolley. When the alarm limits had been set there were no false alarms, and the device gave warning of all the hazardous situations mentioned previously. The operation of the device was understood easily by nursing staff, who became aware quickly of faults occurring in the ventilator/patient circuit. Medical staff, in the intensive therapy unit particularly, liked the screw adjustment for setting the high and low ranges, which ensured that accidental alteration of the controls could not occur. The key-operated on/off switch also prevented accidental switching-off of the device. However, it was thought that the period of muting of the audible alarm (90 sec) for aspiration of tracheobronchial secretions was too long, and if the duration of muting were used as a general guide to the safe period of disconnection of the ventilator and suction of gas and secretions from the respiratory tract, hypoxia might occur. We propose to shorten the muting period to 60 sec.

In clinical use, the alarm functioned normally at airway pressures ranging from 7 cm H₂O to 68 cm H₂O. In one patient, however, airway pressures exceeding 68 cm H₂O were in use and the device could not be used, as the high alarm was activated during each inspiratory phase. Changes in ventilator frequency in the range 8/min to 40/min did not alter the normal function of the unit. The low pressure alarm delay time was only 12 sec in the unit tested; however, this allows for the respiratory frequency to decrease to 5/min before the low pressure alarm operates, a frequency well below the normal clinical range.

No problems were encountered with autoclaving and reassembly of the capsule and “T” piece. The function of the alarm unit was not affected by repeated autoclaving. Battery life during warning of mains supply failure or disconnection was 1 hr 40 min, after which a 24-hr period of charging was required to bring the battery up to full charge again.

The unit is manufactured by Cape Engineering Ltd, Warwick.

RESUME
On décrit dans cet article un petit système d'alarme en cas d'arrêt de la ventilation que l'on peut utiliser avec tous les types de respirateurs pulmonaires artificiels. On peut démonter facilement et passer à l'autoclave l'ensemble du circuit ayant été en contact avec le malade. L'activation de l'appareil se fait au moyen d'une clé amovible et le dispositif d'alarme fonctionne lorsqu'il y a une panne de courant secteur; le signal d'alarme peut être amorti pendant l'aspiration des sécrétions provenant des bronches et de la trachée.

ZUSAMMENFASSUNG

RESUMEN
Se describe un pequeño sistema de alarma para fallo de ventilación que se puede utilizar con todos los tipos de ventilador pulmonar. El circuito completo del paciente se puede quitar fácilmente y es autoclavable. La activación de la unidad se realiza por medio de una llave removible, se proporcione una señal de aviso de fallo de la red, y la alarma puede dejar de sonar durante la aspiración de secreciones del árbol traqueobronquial.