Functional Characteristics of Artificial Ventilators

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The functional characteristics of 5 ventilators, representative of pressure and volume constant apparatus, were studied on a lung model, wherein changes in respiratory compliances and airway resistances could be simulated. The ventilators were set to function at a given volume and rate over a range of three compliances—0.026, 0.069, and 0.111 liter/cm., and through a series of resistances from 0.45 to 46.3 cm. of water/liter/second. Changing pressures, flow characteristics and delivered volumes were recorded. The relative performance of the two classes of ventilators, as well as ventilators in each class are reported.

Method

The studies were carried out on a lung model wherein a ventilator is made to function against a controlled series of compliances and resistances. Figure 1 is a schematic of the lung model. A, B and C were rigid containers and in different combinations represent different compliances. Rigid containers may preferably be employed to simulate compliance chambers. Combinations of chambers were controlled by solenoid valves a and b. Exact pressure-volume relations were obtained by introduction of volumes of air by super syringe and measuring the pressure changes by water manometer. Table 1 lists the range of compliances which can thus be obtained. The chambers led to an airway and thence to a ventilator. In line was a pneumotachometer (PN). It represented one of a series of resistance units which may be placed in line to simulate airway resistance.

Figure 3 is a photograph of the resistance units employed. They were constructed much as a Fleisch pneumotachometer. The impedance to air flow was created by a bundle of glass tubes within each of the units. The differences in resistances between the several units were the result of using tubes of different wall thicknesses and by varying the number of glass tubes in each unit. The units were approximately 15 cm. in length and 0.75 inches inside diameter.

The pressure flow relations in each of the units was determined by passing calibrated air flows through the units and determining the pressure drop across the resistances by taps leading to a differential transducer, the previously calibrated output of which led to a preamplifier which was then amplified and recorded (Fig. 3). From these relations the resistance constants were calculated.

Impedance to air flow is dependent upon both laminar and turbulent flow. The applicable equation is \( P = K_1 V + K_2 V^2 \). Herein \( K_1 \) is the constant related to laminar flow. During laminar flow resistance varies directly with gas viscosity and airway length and inversely with the fourth power of the airway lumen. \( K_2 \) is a constant related to turbulent

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FIG. 1. Diagrammatic representation of lung model.