A DEVICE AND A METHOD FOR MEASUREMENT FOR PULMONARY VENTILATION IN SMALL ANIMALS

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Graphical recording of external respiration in order to obtain a more precise picture of the volume of the expired air has been explored by many authors. For this purpose they have used a kymograph and contact gas meters whose pointer made an electrical contact connected in circuit with an electrical marker and power supply [1]. More complex devices have been used, but in most cases they have been based on flow-meters, and have been designed for use with animals having a ventilation rate of 4,000-5,000 ml per minute or more. When the external respiration of a rabbit (in which the volume of a single respiratory cycle is 3-15 ml) is to be recorded, the ordinary flow-meters cannot be used because they are not sufficiently sensitive to record the small volumes of air.

We have constructed a device for measurement of pulmonary ventilation in the rabbit (Fig. 1). A mask is hermetically fixed to the mouth and nose (Fig. 2, 1), with an input valve (2) and output valve (3). The hermetic connection is made by means of fine glove-rubber fixed to the mask. We have used the expired air which passes through the output valve along the rubber tube (4) having a diameter of 12 mm whence it flows into a special chamber (5) made of perspex. The volume of the chamber is 200 ml. The input aperture has a mica valve (6) which operates electrical contacts (7). When the contacts close, the circuit of the windings of the electromagnet (8) connected with the valve (9) is completed, with the result that the aperture of the chamber is open during respiration. The principle of operation is to create a certain pressure in the chamber proportional to the amount of expired air. Pressure of air within the chamber acts on the rubber membrane (10) * and on the membrane of the pneumatic chamber (11). For construction of this chamber we used the case of a vibrator type MOV-2, which allowed recordings to be made on oscillograph type MPO-2. Before entering the chamber the expired air passes through heater (12) whose function is to evaporate moisture to avoid any condensation on the mica of the valve. The heater consists of a quartz tube of diameter 10 mm with a nichrome wire of diameter 0.1 mm wound over it. The electrical resistance of the heater for a 127 v supply is 1,500 ohm. The electrical supply for the valve device is produced by a rectifier. A transistor diode D7-Zh incorporated in a bridge circuit may be used as rectifier.

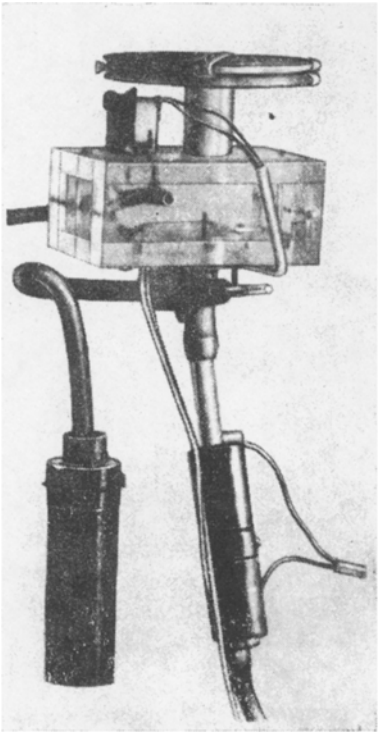


Fig. 1. General view of the device for measurement of pulmonary ventilation.

*The rubber membrane may also be used for recording on a normal kymograph.

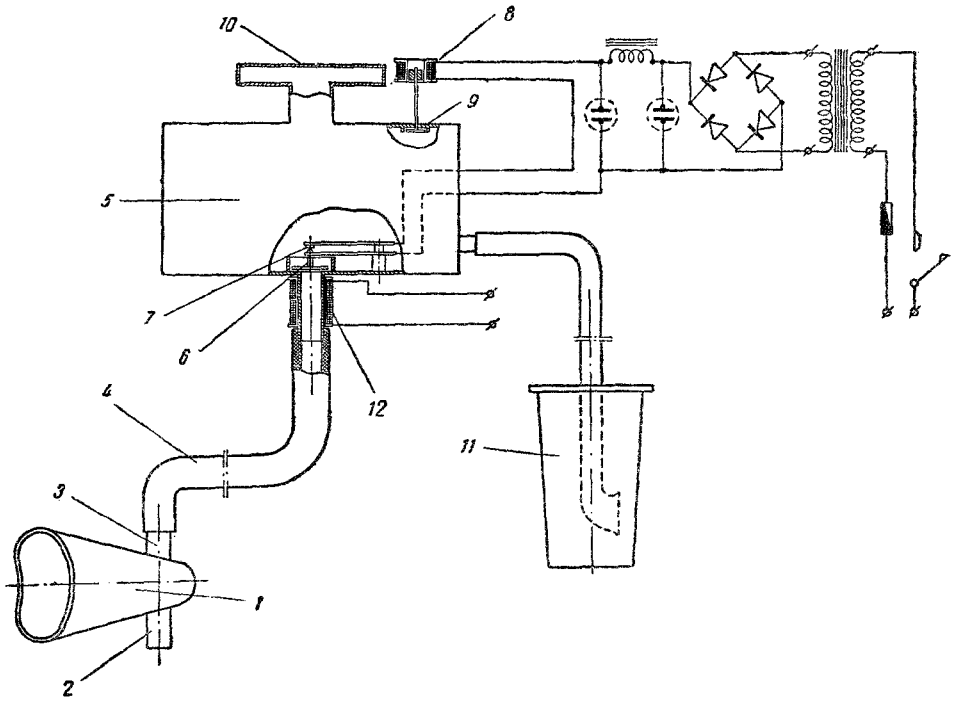
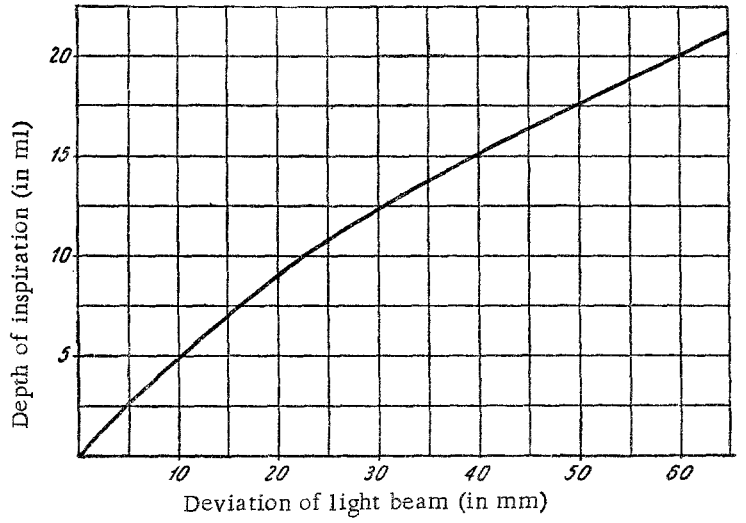


Fig. 2. Diagram of a device for measurement of pulmonary ventilation.

a



b

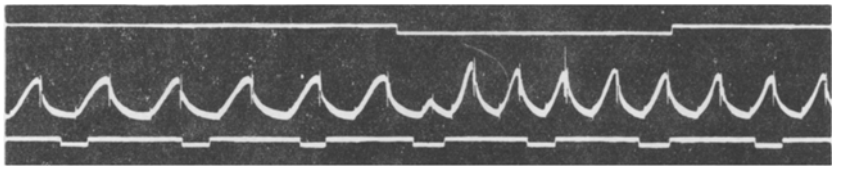


Fig. 3. a) Calibration graph for measurement of pulmonary ventilation; b) change of pulmonary ventilation in a rabbit under the influence of electrical cutaneous stimulation. Curves, from above downwards: stimulus marker; respiration record; time marker (one second).

For calibration of the device we used a 20-gram Luer's syringe which under control recording on the oscillograph supplied air into the rubber tube (1). From the deviations of the light beam of the oscillograph on the photographic film we constructed the graph shown in Fig. 3, a, which we then used to interpret our own recorded observations.

Instead of electrical time and stimulus markers the string oscillograph was connected into the circuit.

We will give an example of a record of respiration from a rabbit (Fig. 3, b). In response to electrical cutaneous stimulation an increased respiration rate was observed. Before stimulation 3-4 respiratory movements were recorded during a 2 second period, and after stimulation the number increased to 5. Also, stimulation was associated with an altered depth of respiration. Before stimulation the deviation of the light beam at each inspiration and expiration was 28 mm^1, which, from our graph, corresponded to 12 ml; after the action of the stimulus at first respiration was suppressed (10 mm – 5 ml), and then increased (42 mm – 16 ml, 40 mm – 15 ml, 38 mm – 14 ml, 38 mm – 14 ml). On average during the action of the stimulus the depth of respiration was 12.8 ml, and the frequency was five respiratory movements in two seconds. The pulmonary ventilation in this period of time was 640 ml. Consequently during the action of the stimulus the minute volume was 1920 ml (640 × 30).

Thus at the beginning of the experiment the pulmonary ventilation was 1200 ml per minute (depth of respiration 12 ml, frequency 100 per minute), and under the influence of electrical cutaneous stimulation it increased considerably. The increase was 160% of the original amount.

The results given indicate that the device we have described and the method may give an objective quantitative record of the principal parameters of external respiration.

SUMMARY

We have described a device which allows accurate measurements to be made of pulmonary ventilation in rabbits. A pressure proportional to the pressure of the expired air was developed in a perspex chamber specially designed for this purpose. A MPO-2 type oscillograph was used as recorder.

A method of interpreting the respiration curves is given.

LITERATURE CITED

1. E. V. Gubler, E. A. Kovalenko, G. Sh. Basadze, et al., Fiziol. zh. SSSR, No. 6 (1957) p. 582.
