AN ARTIFICIAL RESPIRATION APPARATUS FOR LABORATORY ANIMALS

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To maintain respiration in experimental animals during acute experiments, the author has constructed an apparatus providing for the maintenance of inspiration and active expiration, regulation of the depth, duration, and frequency of respiration, and adjustment of the relationship between the phases of inspiration and expiration.

Air for the apparatus is supplied from a compressor or a bag, using either compressed air or a mixture of oxygen and carbon dioxide in the required proportion.

The apparatus (see figure) consists of a system of tubes along which the air is passed, of distributing valves (1 and 2), an electromagnet (3), a trigger relay (4), and a mercury manometer (5) with electrodes (6 and 7). The apparatus works off the 220 V mains. Before switching on, one tube (8) is connected by a rubber hose to the compressed air supply (the compressor or bag), and another (9) is connected also by a rubber hose to a cannula inserted into the animal's trachea. After switching on the tap on the bag of compressed air is opened or the compressor started up. Air enters through the open valve (2), the injector (10), and escapes through the tube (11) to the outside. The negative pressure thus created in the injector leads to the aspiration of air from the lungs if the valve (2) is open, i.e., active expiration takes place. The negative pressure is transmitted along the other tube (12) to the mercury manometer, as a result of which the mercury column in the right limb of the manometer is forced upward. In the figure, A, the broken line indicates the direction of the flow of air in the system of tubes during expiration.

As soon as the column of mercury touches the electrode (7), the electromagnet (3) is switched on, and this in turn closes one valve (2) and opens the other (1). Expiration stops and inspiration starts. Air through the open valve (1) passes along the tube (9) into the lungs and along the tube (12) to the mercury manometer. In the figure, B, the broken line shows the direction of the flow of air in the system of tubes during inspiration.

The mercury column in the right limb of the manometer begins to fall and that in the left limb begins to rise. Contact is broken between the electrode (7) and the mercury column in the right limb of the manometer, but the electromagnet (3) is not switched off, because it receives its supply through its own contact closed when the electromagnet is switched on. In this manner, the act of inspiration continues. In the lungs and the right limb of the manometer the pressure rises, and the mercury column in the left limb of the manometer touches the electrode (6), operates the relay (4) and opens its own contact, as a result of which the circuit feeding the electromagnet is broken. The electromagnet (3) is switched off, and by means of a spring (13) the valve (1) closes and the valve (2) opens. This causes inspiration to stop and expiration to start. The cycle is then repeated.

The depth of inspiration and expiration, the frequency of respiration, and the relationship between the phases of inspiration and expiration can be regulated by raising or lowering the electrodes (6 and 7). When the electrode (6) is raised, deeper and more prolonged inspiration takes place and conversely, when it is lowered, inspiration becomes shallower and shorter in duration. When the other electrode (7) is raised, expiration becomes more prolonged and if it is lowered it becomes shorter.

To prevent the oscillation of the mercury in the manometer acquiring an intrinsic frequency of their own as a result of the inertia of the mercury in the rubber tube connecting the two limbs of the manometer, a screw clip (14) is fixed. By compressing the rubber tube with this clip, the intrinsic oscillations of the mercury in the manometer are prevented. The same clip can be used to regulate the frequency of respiration without affecting the relationship between the phases of inspiration and expiration.

In the figure, C, the scheme of the valve is shown in its exploded (a) and assembled (b) form. Sheets of plastic (getinax, Viniplast, or organic glass) can be used for making the valve.

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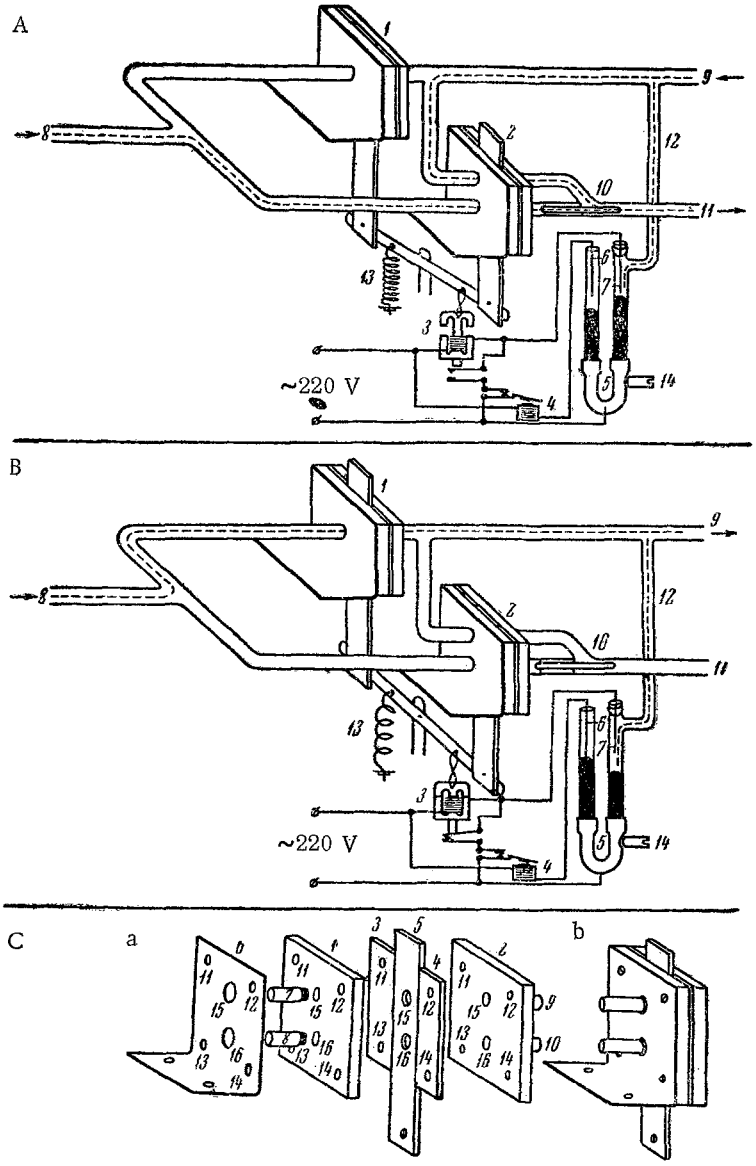

Scheme of construction of the apparatus and of its operation: A) expiration; B) inspiration; C) construction of valves. Explanation in text.

Plastic gaskets (3 and 4), 1.5-2 mm in thickness, are placed between two plates (1 and 2), 5-6 mm in thickness and measuring 25 × 30 mm, in such a way that a space for the valve (5) remains between them. The thickness of the valve and the gaskets must be equal. When the plates (1 and 2) and the gaskets (3 and 4) with the valve (5) have been cut to the correct size, holes (11-16) are drilled. To ensure that these holes coincide, the plates, the gaskets with the valve, and the vertical part of the angle bracket (6) are clamped together in a vise and the holes drilled.

The metal tubes (7-10) are screwed into the holes (15 and 16), for which purpose a thread is cut on the tube and in the holes in the plates (1 and 2). The plates with the gaskets are fixed inside the angle bracket by means of bolts inserted into the holes (11-14). The bolts are screwed up to such a degree that the valve (5) moves freely and gives hermetic sealing. The horizontal part of the angle bracket with its holes serves for attaching the valve to the base board of the apparatus. The angle bracket can be made of sheet aluminum. The apparatus is mounted in an aluminum case measuring 15 × 15 × 15 cm and its total weight is 1.5 kg.

The valves, the system of air supply tubes, and the regulating screws for raising and lowering the electrodes are fixed to the top panel of the apparatus. Examination slits are cut in the side wall of the apparatus through which the movements of the mercury column in the manometer and the electrodes can be seen when the apparatus is working. A scale fixed to the manometer shows the air pressure in the lungs (in mm Hg) during inspiration and expiration.