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# A NEW ARRANGEMENT FOR THE REGISTRATION OF DIAPHRAGM MOVEMENTS

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NUMEROUS curves reproducing the behaviour of the diaphragm have been published during the last few years. The registration of the movements has been made partly with an open thorax and artificial respiration, partly with a closed thorax. The following methods have been used by various authors:

Hess (1936): "For this purpose we used a lever, which has on the lower end a small, flat, hollow dish turned towards the dome of the diaphragm. If suitably placed, the dish follows the movements of the diaphragm. The lever is connected to a Marey's tambour, whose movements are transmitted pneumatically to a tracing capsule which registers the movements."

Verzàr, Szécsényi-Nagy, Haffter, & Wirz, (1937): "For registering the movement of the diaphragm a light spoon made of aluminium foil is sewn flat on to the central tendon of the diaphragm. This was tied over the axis by means of a thread, which traces the movements on a myograph."

Van Voorthuysen & ter Braak (1937): "The diaphragm movements are registered by means of a bent copper lever, which is inserted through an incision in the right abdominal wall between the dome of the diaphragm and the liver. The other end of this lever presses on a tambour, connected by means of a tube to a second tambour placed in front of the slit (in the optical kymograph[1])."

Eichler & Klein (1936): "We opened the abdominal cavity through a longitudinal incision in the linea alba of the animal, introduced a small silver hook into the serosa of the upper muscle fibres of the muscular part of the diaphragm, and connected it to a tracing lever by means of a thread.... The thread was passed through a glass tube, around which the opening in the linea alba is closed up."

Killian & Kuhlmann (1937): "The registration of the movements of the diaphragm is undertaken by means of a special diaphragm spoon by indirect mechanical transmission. The diaphragm spoon is pushed through a slit in the anterior abdominal wall between the top of the liver and the top of the diaphragm. It remained undisturbed for the entire duration of the experiments. The actual registration was undertaken photographically.

In investigating the circulatory action of respiratory stimulants, we were interested in the behaviour of the pressure in the pleural and abdominal cavities in connexion with the movement of the diaphragm. For this purpose, it was necessary for the physiological respiratory

[1] Not in the original.

mechanism to be disturbed as little as possible and for the bodily cavities to be closed. For these reasons we were not able to use without modification the previously utilized methods. Moreover, it seemed to us to be particularly important to make the movements of the tracer independent of the movements of the musculature. After various attempts, which we carried out with the support of our technical expert, Mr Helmich, we succeeded in devising an arrangement which satisfies the above-mentioned demands. The apparatus is illustrated in Fig. 1. It consists of a

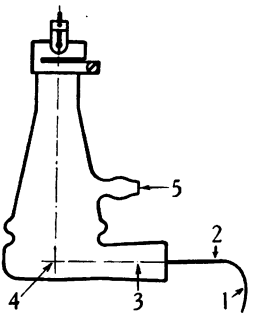


Fig. 1.

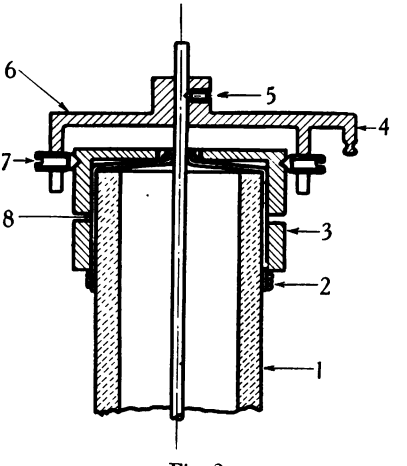


Fig. 2.

Fig. 1. Side view of the diaphragm recorder in the glass vessel. 1, Diaphragm spoon; 2, flat-edged stem; 3, hollow tube; 4, joint; 5, glass inlet for registering the abdominal pressure.

Fig. 2. Section through the top of the tracing apparatus. 1, Glass vessel; 2, thread used for tying on the rubber membrane; 3, metal cap; 4, hook for fastening the thread; 5, screw; 6, metal piece; 7, imaginary axis; 8, rubber membrane.

lever system which is built into a flat glass vessel. On the front of the lower arm of the lever a light, flat, spoon-shaped piece of copper is attached which is sewn on to the central tendon. If rabbits are chosen as the animals to be experimented on, the use of a very fine arterial needle and silk 00 is necessary for the prevention of pneumothorax. A head-lamp or a reflector facilitates considerably the work, as also does the use of a very long needle-holder and two pairs of large tweezers. The arm of the lever bearing the spoon-shaped piece of copper passes through the lower tube of the glass vessel to the actual registering lever, to which it is connected by means of a joint. The movements are thus transmitted to the lever arm, which is seen in a vertical position in Fig. 1. The lever can

move quite freely in the triangular glass vessel. Fig. 2 shows the way in which it is mechanically attached, the plane of the diagram being at right angles to that in Fig. 1. The glass vessel is hermetically sealed by means of a thin rubber lamella through which the rod passes. In order to guarantee the greatest possible freedom of movement the rubber is tied on to the rod at the height of the imaginary axis. The rod is fastened to a metal top-piece which forms the external axis. Attached to this metal top-piece is a hook to which the thread leading to the registering apparatus is fastened. The movements can then be recorded on a smoked kymograph or, as in our case, optically. After fixing the lever the glass vessel is sewn into the linea alba and the muscles and skin are carefully adapted to it, if necessary using a rubber cover fixed on the glass vessel. The contrivance for closing the abdominal cavity can be tested to see if it is completely airtight by blowing in air. The registration of the abdominal pressure can similarly be carried out without difficulty, by means of the glass connexion. This appears to us an advantage, since in the case of the system of registration by means of a rubber balloon the direct pressure of the musculature on the latter cannot be excluded. In addition, since it is a closed system its internal pressure is not absolutely uninfluenced by other factors, e.g. temperature. It is true that the fixation of the abdominal wall and of the linea alba to the glass vessel is necessary, but according to our experience this incurs no essential disturbances of the physiological respiratory mechanism.

By means of our apparatus it is possible not only to trace exactly the single movements of the diaphragm but also to observe any alteration in position under physiological conditions. The correct registration of the diaphragm movement and position can be controlled by the abdominal pressure which is recorded at the same time. The mechanical registration of the movement can, moreover, be directly observed in the transparent glass vessel during the experiment. Figs. 3 and 4 are examples of curves obtained. Fig. 3 shows part of a curve obtained with the normal animal which was taken with a rapidly moving kymograph. Without going into details we would refer only to the diaphragm movement, which is represented in proportion to the other registered pressures in the bodily cavities, and the movements of the thorax and of the abdominal wall. The importance of these relations is discussed in more detail elsewhere. Fig. 4 is a curve from which the alteration in tone of the diaphragm by means of histamine can be easily recognized. Further examples of the application of the method are given in a paper by Meier & Müller [1938].

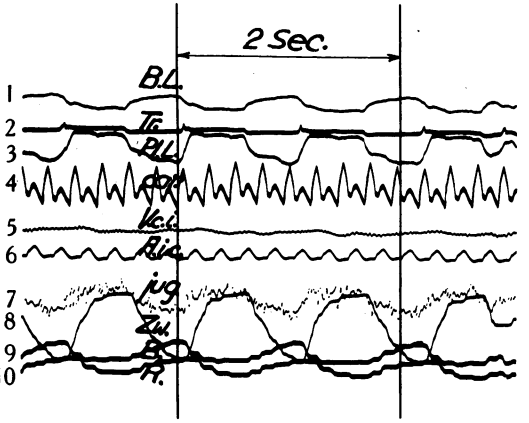


Fig. 3. Registration with rapidly moving kymograph. Normal respiration in the rabbit. 1, Pressure in the upper abdomen; 2, pressure in the trachea (respiration through a valve); 3, pressure in the pleural cavity; 4, blood pressure in the carotis communis; 5, pressure in the vena cava inferior; 6, blood pressure in the arteria iliaca communis; 7, pressure in the vena jugularis externa; 8, diaphragm (inspiration downwards); 9, movement of abdomen; 10, movement of the fifth rib.

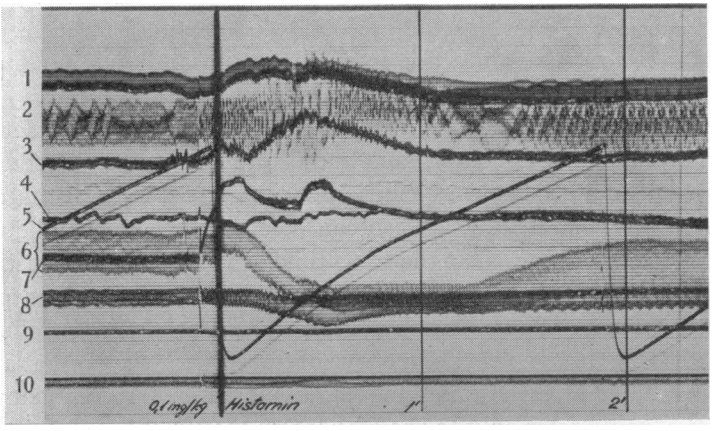


Fig. 4. Registration with slowly moving kymograph. Action of 0·1 mg./kg. histamine on the rabbit. 1, Blood pressure in the arteria carotis communis; 2, pressure in the vena jugularis externa; 3, pressure in the vena cava inferior; 4, movement of abdomen; 5, volume respired (measured with a spirometer): the interval between two maxima is an indication of the time in which 3 l. are breathed; 6, diaphragm, inspiration downwards; 7, movement of the fifth rib; 8, pressure in the pleural cavity; 9, pressure in the upper abdomen; 10, pressure in the trachea (respiration through a valve).

SUMMARY

An apparatus is described which makes possible the exact registration of the movements of the diaphragm and its position with closed abdominal and pleural cavities.

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