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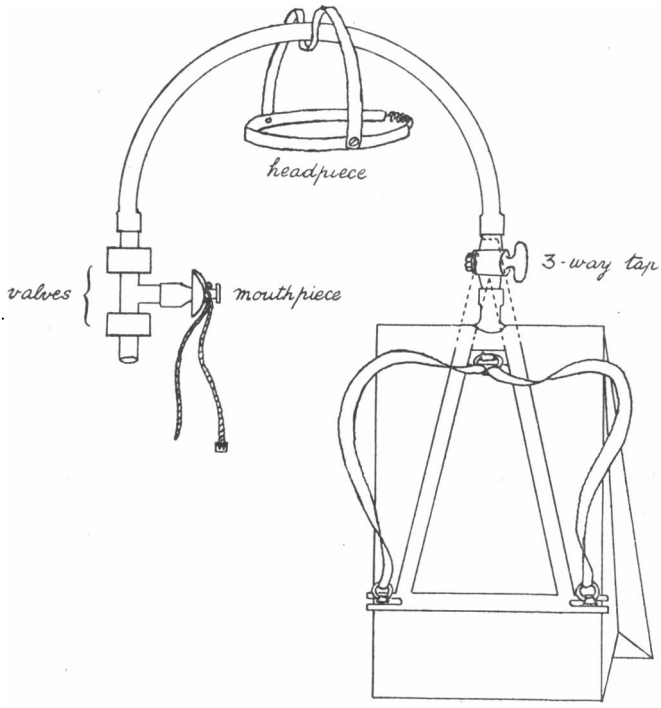
A method for determining the total respiratory exchange in man. By C. GORDON DOUGLAS.

In this method the whole of the expired air is collected over a short period. The subject breathes through a mouthpiece connected with inspiratory and expiratory valves. The expired air is directed along a rubber pipe of large calibre which passes over the head, the further end being connected with a wedge-shaped gas bag made of twill lined with vulcanised rubber which holds about 50 litres. The gas bag is supported on a triangular wooden frame to prevent it from sagging, and is carried on the back in the manner of a 'rucksac' by means of two straps passing over the shoulders. Interposed between the end of the rubber pipe and the bag is a brass three-way tap of large bore, in order that the subject may breathe through to air or into the bag at will. A metal framework is worn on the head in order to keep the rubber pipe in position, and to bear the greater part of the weight of the valves.

In making an experiment the subject breathes for a sufficient time through to air to ensure his being in respiratory equilibrium under the particular experimental conditions chosen, and the tap is then turned so that the expired air accumulates for a definite period in the bag. After closing the tap the apparatus is removed from the subject, and the rubber pipe disconnected from the expiratory valve and attached to a gas meter. The gas is then thoroughly mixed by repeated pressure on the bag, the tap turned, and whilst the gas is being measured in the meter a sample for analysis is taken off from the rubber pipe. In

performing the experiment under resting conditions the bag may of course be placed on any convenient support.

The gas bag must be carefully examined to see that the rate of diffusion of the gases through its walls is negligible. Both before and after the experiment the bag is emptied by rolling it up and pressing on it. The residual air left may be estimated and allowed for. It is however simpler to fill the bag with expired air at the start before emptying it, for then, as the composition of the residual air in the bag will be much the same both at the start and at the end of the experiment, no appreciable error will arise.



The advantages of the method are the lightness of the apparatus and its portability, the ease of adjusting it to the subject, and the fact that the necessary manipulations can be done by the subject himself without external help. The method is equally adapted for determining the total respiratory exchange during rest and under conditions of even violent muscular work, such as running, and is particularly suitable for the examination of clinical cases. Different sizes of gas bags may be used to suit the required duration of the experiment.

Dissociation of auricles and ventricles in hibernating dormice. (Abstract.) By F. BUCHANAN.

The facts relating to one dormouse awaking from hibernation recorded in my communication of last July, have been confirmed in four others (all that have been investigated) and the observations extended to stages of greater torpidity. Calling the electrical changes which obviously relate to the ventricles "*v*," those which obviously relate to the auricles (*i.e.* which occur at a definite time-interval before each *v*-effect in a series) "*a*," and those which occur as an independent series "*b*," the behaviour of the latter suggests that each *b*-effect represents the electrical counterpart of an extrasystole either of both auricles or of the left auricle only, provided that no other structures than the auricles and ventricles of the heart are capable of producing distinct electric fields appearing and disappearing at more or less regular intervals of time. The *b*-effect may be simple and like the *a*-effect (Einthoven's "P") but is more frequently of a much longer duration, sometimes having the appearance of two or three simple effects recurring in quick succession. The difference of potential is always considerably less than that of a *v*-effect ($\frac{1}{5}$ to $\frac{1}{10}$ of it), the duration often three or four times as long.

When the animal is very torpid, showing no sign of respiratory movements for several consecutive minutes and having a pulse-frequency of from 12 to 30 a minute, the records show nothing but *v*-effects (in half-minute samples) recurring at irregular intervals, the more irregular the lower their frequency. The ventricular effects so often indicate that the succession of events is slow that it is difficult to conceive that auricular effects would not also manifest themselves did they exist, and the records obtained when the *v*-effects have become somewhat more frequent, and more regular, lend support to the view that when the animal is in its deepest sleep it is the ventricles only that are beating. For when the *v*-frequency has come to be about 40 a minute there appear at quite irregular intervals, most of them much longer than the *v*-intervals, well-marked *b*-effects each of long duration. These gradually increase in frequency and in regularity. Usually before the *v*-frequency has become 100 a minute, the *b*-frequency has overtaken it, but on more than one occasion and with different dormice the ventricles

were not overtaken until their frequency was nearly 300 a minute. When once the *b*-frequency is in advance it never falls behind again for more than a few beats at a time. The *b*-series is less regular than the *v*-series until it has overtaken it, but while being overtaken the *v*-series is apt to become irregular, one or more *v*-effects being dropped here and there while the *b*-effects continue, giving the records the appearance familiar in cases of complete heart-block produced by vagus stimulation in other mammals. Even when the two series are nearly at the same rate they are usually absolutely independent of one another, now the one alone, now the other being accelerated or retarded for a few seconds. Occasionally however the *b*-series seems to be arrested by the *v*-series and brought into unison with it for a time, the auricular effects immediately following the ventricular for several seconds, then the *b*-effect getting in front of the *v*, the *b*—*v* interval increasing rapidly in the next few beats until the *b*-effect again immediately follows a *v*-effect, when its rate is once more reduced to that of the *v*-series.

The respiratory movements are sometimes slower than either the *v*- or the *b*-effects, sometimes of about the same frequency as either the one or the other until these approach 200 a minute. When the breathing is of the Cheyne-Stokes type the *b*-effects are absent during each period of apnœa, apparently disappearing just before the apnœa begins, and reappearing just before the breathing begins. If simultaneous records of the respiratory movements can be taken and they confirm this, it would suggest that it is those changes in the blood which are known to affect the respiratory centre which are first directly or indirectly responsible for the presence or absence of the auricular extrasystoles presumably represented by the *b*-effects. I use the word "extrasystole" in reference to these because I have found no evidence of their influencing at any time the ventricular frequency, and because other effects which appear to be the counterparts of ordinary auricular systoles may occur side by side with them. These *a*-effects only began to be visible as the season advanced or perhaps as the number of times the animal was roused from hibernation increased. They do not at first always occur regularly before each *v*-effect and I have not hitherto seen them with any *v*-frequency lower than 58 a minute. The *a*—*v* interval is then long, about 0·3 sec., shortening to about 0·12 sec. as the *v*-frequency rises towards 150. Owing to the difficulty in following them as everything quickens I have not yet been able to trace their final relations to the *b*-effects.

The frequency of the heart-beat in bats and hedgehogs and the occurrence of heart-block in bats. By F. BUCHANAN.

BATS.

Electrocardiograms taken during the winter of bats of two different genera, awake and warm, with ear (or in *Pl. auritus* ear-cover) and hind-leg connected with the two terminals of the capillary electrometer, showed that the frequency of the ventricular beat was most irregular, *e.g.* the number of *v*-intervals in 11 successive seconds was on one occasion: 10·5, 10·3, 11·5, 11, 9·2, 8·7, 8·3, 10·2, 11·8, 10·8, 12, indicating frequencies varying between 508 and 720 a minute (*N. pipistrellus B.*).

In this mild winter it has been difficult to get any of these bats to hibernate properly, *i.e.* although they have often become quite cold to the touch they have not gone to sleep and have even while cold displayed considerable ingenuity in setting themselves free.

Plecotus auritus, 9·4 grms. Pulse frequency when awake and warm varying during December from 600 to 900 a minute. In January, once after one night of frost and once after four nights, records were taken at intervals of a few minutes for 1 or 1½ hours with the animal cold and fairly quiet but with its eyes open and moving its wings every now and then. Both *a*- and *v*-effects manifested themselves in all, their frequency at the beginning of each morning being 76–77 a minute. On the first occasion it increased to 145 in 1 hr. and to 182 a minute in 1½ hrs., the *a*—*v* interval having been reduced from 0·22 to 0·13 in 1 hr. and to 0·095 in 1½ hrs. There was no indication of a heart-block. On the second occasion after the longer exposure to cold the frequency of the *v*-effects increased much more slowly, though the morning after the four nights of frost was warm. It only went up to 89 in 1 hr. The *a*—*v* interval, however, was reduced as much as before, though it was not very regular: it varied between 0·22 and 0·25 sec. at first, and an hour later was 0·13 or 0·14 sec. The last record taken showed a second series of effects similar to the *a*-effects, one occurring between each two *a*-effects but not half way between them. I take these to be also counterparts of auricular systoles whether they belong to the same series as the others or not. If they do we should have here a case of 2:1 heart-block. The actual intervals between the effects, when this record was taken were: for the ventricles, 67, 68, 68, 67, 67, 68, 68, 67, hundredths of a second; for the auricles, 31, 36, 67, 32, 35, 33, 35, 33,

34, 67, 27, 40, 25, 42. The bat died a fortnight later on the first night of another frost.

Nannugo pipistrellus, two specimens (*A* and *B*). *A*, 4·3 grms. Pulse-frequency during December, when awake and warm, varying within an hour from 100 to 800 a minute or from 230 to 972 on different occasions. On the second occasion the prevailing frequency was about 660 a minute. The *v*-effects were extremely brief and no *a*-effects manifested themselves at all in any of the records taken with this bat, with one exception in which the focus was exceptionally good. In this an *a*-effect occurred regularly before each alternate *v*-effect, the *a*—*v* intervals varying however between 0·02 and 0·03 sec., the *v*—*v* interval being 0·143 sec. indicating a frequency of 420 a minute.

B (4·1 grms.) after exposure for 24 and 48 hrs. respectively to artificial cold became itself cold to the touch but was extremely active even with a pulse-frequency no more than 30 a minute. Records obtained when the voluntary movements of the bat were not exerting a disturbing influence showed no sign of other than *v*-effects when the frequency of these was under 30 a minute. With higher frequencies other and smaller effects occurred sporadically, and in one record in which the *v*-frequency varied from 175 to 150 a minute during 8 seconds, these other effects varied in frequency during the same time from 210 to 180 to 210 to 270 a minute.

Fragmentary as these observations are they serve to show that evidence of heart-block, complete or incomplete, is likely to be forthcoming in hibernating bats.

Hedgehog.

A hedgehog, weighing 520 grms., awake and warm, had a pulse frequency varying between 280 and 320 a minute. It was very fairly regular.

Another hedgehog when cold but breathing and in a not very sound sleep had one of 48 a minute, rising in half an hour to 70 a minute.

Owing to the difficulty in making a good contact with the skin the *v*-effects only just manifested themselves in the electrocardiograms and one can infer nothing from the fact that no other excursions of the meniscus were visible.

(The expense incurred in both the above researches has been defrayed by a grant from the Royal Society.)