circuit is obtained when the light intensities on the two phototubes are maintained at a constant ratio close to unity. Constant intensity ratio in an absorption photometer is achieved by employing a light gate to adjust the intensity in at least one of the light beams. When a light gate is employed, light absorption measurements can be made over the full range from 0 to 100% absorption. When a light gate is not employed and only the unbalance voltage of the bridge is measured, the range is restricted to 10 to 30% absorption, depending on the magnitude of the bridge potential. The calibration of the electrically unbalanced photometer is nearly linear over the useful range described, and the sensitivity drops off rapidly beyond this range. Measurements of light absorption with this circuit of the order of 0.001% can be reproducibly recorded.

The circuit is remarkably free from instability and drift. If the two phototubes have identical slopes and heights for the saturation portion of their characteristics curves, then when the relative illumination on the two tubes is maintained at a constant ratio, the output reading of the photometer is independent of bridge voltage. With commercial tubes, slight differences in slope and in height (or sensitivity) occur. The sensitivity difference is accommodated by using light intensities on the two tubes that are in inverse proportion to sensitivities of the tubes. The slope difference introduces a small voltage coefficient into the zero reading. This can be compensated by rapid trial-and-error selection of the relative values of the two bridge resistors.

A source of large drifts stems from the dependence of phototube response on absolute temperature. Although the effect is quite small by ordinary standards, it introduces errors when light absorption is measured over narrow ranges, such as 0 to 1%, or when stability over long periods of time, such as 24 hr, is required. The difference in the temperature coefficients of sensitivity between randomly selected Type 935 phototubes is often so large that a spurious absorption reading of 0.05% is introduced for 1° C change in temperature. This effect can be minimized by preselection of tubes, by thermal jacketing and temperature control, or by frequent zeroing of the photometer.

Major drifts and instabilities encountered in the use of this bridge are often caused by associated components. Changes in the color or color temperature of the source will unbalance the bridge, when the two phototubes have different spectral sensitivities. Many temperature effects may occur, including change in transmission of color filters, thermal expansion of mechanical members in the light paths, and drift of the voltmeter. Other sources of error are accumulation of dust at different rates on members in the two light beams, and accumulations of light-absorbing gases or vapors in different amounts in the two light paths. These difficulties can be minimized by good design of the apparatus, and the full capabilities of the series-aiding phototube bridge can be realized.

A Simple Instrument for the Determination of ACH[1]

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The use of the contraction of the *rectus abdominus* muscle of the frog for the determination of acetyl choline is well known (*1*). The simple instrument described here eliminates the traditional smoked-drum kymograph and in its place uses a lightweight cantilever beam equipped with resistance wire strain gauges in a bridge circuit. The output of the bridge is recorded on a Brown strip chart recorder.

The strain gauges are of the paper kind (Baldwin Locomotive Works, Type A-7) and have a resistance of 120 ± .3 ohms and a gauge factor of approximately 1.92 ± 2%. Four of them are mounted on a Starrett feeler gauge which serves as the beam. The feeler gauge is of steel, 6″ long, ½″ wide, and .008″ thick. The width tapers from ½″ in the center to about ¼″ at one end. The beam is mounted between two pieces of brass of dimensions 4″ × 1″ × ¼″ (Fig. 1). About

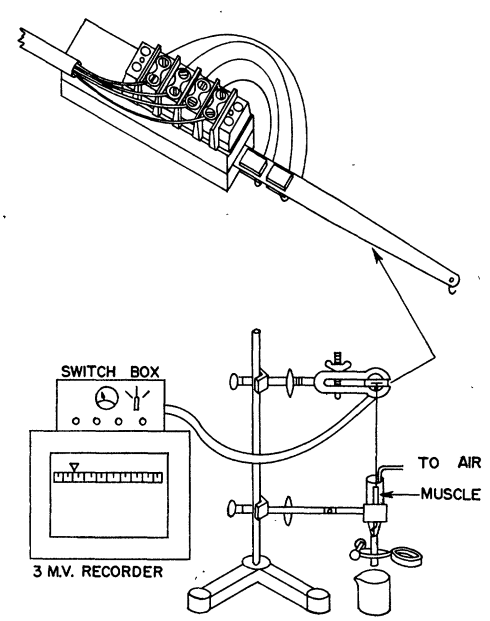

FIG. 1. Arrangement of strain gauge beam and frog muscle for ACH determination.

¼″ of the beam is clamped between the brass mounts. The four strain gauges are cemented to the beam (two on top and two on the bottom) ⅛″ from the clamped end, with Duco cement, according to the instructions of the manufacturer. After the gauges have dried thoroughly they are connected in a bridge circuit so

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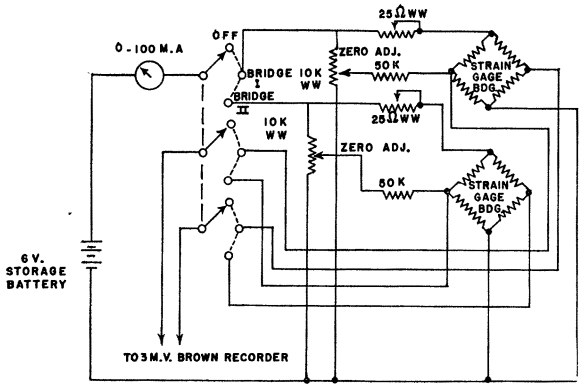

FIG. 2. Diagram of switch box for two strain gauge beams.

that the two gauges that will be in tension and the two that will be in compression are in opposite arms of the bridge. With the bridge connected in this manner maximum unbalance is obtained under strain. The use of four active gauges automatically provides temperature compensation. The leads from the gauges are extended with small flexible wires brought out to a terminal strip on the brass blocks, where connection is made through a four-wire cable to the switch box, the wiring diagram of which is shown in Fig. 2. This box provides for switching either of two beam outputs to the recorder. It also contains a 0–100-ma meter for reading the bridge currents, two balance or zero controls, and two current controls. The current for the bridges is supplied from a 6-v storage battery, normally set at 48 ma. This gives a sensitivity of 3 g full scale on the recorder, which has a voltage sensitivity of 3 mv full scale.

Fig. 1 shows the arrangement of the beams and the muscle in the ACH determination. The muscle is suspended in a 15-ml bath of eserinized amphibian Locke solution. One end is fastened to a hook in the bottom of the bath, and the other by means of a silk thread to the end of the beam. Air is slowly bubbled through the bath at all times. When a solution is to be tested the Locke solution is drained by means of the pinch clamp and is replaced with the unknown. After the recorder reading has reached a maximum value the muscle is rinsed with the Locke solution and allowed to relax in the bath before the next determination is made. This requires 10–20 min. This relaxation may be speeded up by applying a small amount of tension to the muscle.

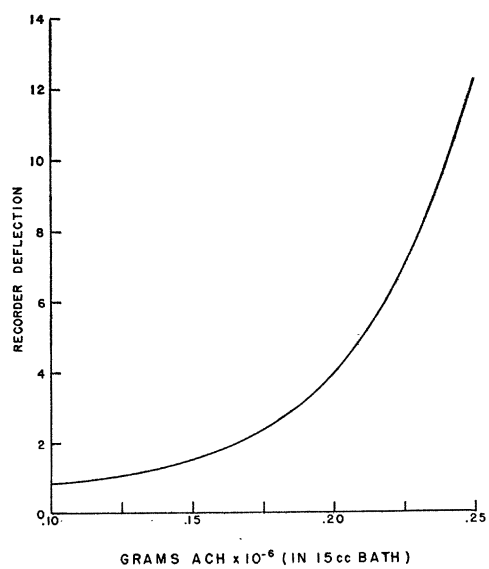

FIG. 3. Typical curve for *rectus abdominus* muscle.

A typical curve is shown in Fig. 3. It should be noted that this method of determining ACH differs from the lever and smoked-drum method in that the latter keeps the muscle under a constant load (usually around 5 g) whereas with the cantilever beam the muscle is loaded by a spring. For purely analytical purposes, however, this difference does not influence the usefulness of the method described above.

Reference

1. GERARD, R. W., Ed. *Methods in Medical Research*, Vol. 3. Chicago: Year Book Pub., 87–88 (1950).

Barostat for High-Altitude Chamber

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A large low-pressure chamber (9′ × 22′, including lock) for investigations at high altitude has been in use at this laboratory since 1942. In order to maintain accurately a given pressure level in the chamber during a run, it was necessary to readjust the controls occasionally because of the fluctuation in the pressure caused by the exhaust from air-operated apparatus being used in the chamber, occasional operation of the small medical lock, and drift up and down, which was due to the difficulty of accurately balancing the vacuum pump pressure against the ventilation bleed. Practically all the early use of the chamber has been with human subjects; consequently the pressure levels at which the chamber was operated were manually controlled, and continuous attendance was necessary. During the past few years, however, the chamber has been used for animal work which required long exposures (up to 24 hr) at various altitudes. In order to obviate the need for continuous manual control during these tests, a type of barostat was devised to control automatically the pressure level after it had been set manually.

The barostat (Fig. 1) consists of a 30-gal cylindrical steel tank (*A*) located outside the altitude chamber and connected with 1-in. pipe through the chamber wall (*B*) to the stationary side of a bellows within the chamber. The bellows (*C*) consists of two 9-in. metal disks in parallel position, over which is sealed a section consisting of 3 convolutions (*D*) cut from a large rubber bellows (type used in waterless metabolism