whole body. Decapitation of a roach showing violent nicotine tremors caused the tremoring posterior to the neck to stop at once. Conclusion 6: DDT applied in this way does not cause general excitation, as does nicotine.

General discussion.—These results indicate that the action of DDT was different from that of nicotine, the latter affecting the ganglia and DDT affecting the nerves somewhere along their length. The results suggest that the DDT can act more readily on the motor than on the sensory fibers and, further, that the DDT can bring about repetitive discharges of nerve impulses somewhere along the motor fibers.

General conclusion regarding a mode of toxic action of DDT in the roach.—Certain symptoms of toxicity, referred to as typical DDT contractions and tremors of a leg, can result from the action of DDT at a site (or sites) common to leg and body. It is strongly indicated that the site (or sites) referred to consist of that region of a nerve lying between the origin of its fibers in the ventral nerve cord and the terminations of its fibers in the leg exclusive of the origin and the endings, that is, the myo-neural junctions, of the fibers. It may be said also that all these results are consistent with the idea that DDT can provoke contractions and tremors in other appendages, or in the body, by acting at a similar site on other nerves.

J. FRANKLIN YEAGER
SAM C. MUNSON
AGRICULTURAL RESEARCH ADMINISTRATION,
BUREAU OF ENTOMOLOGY AND
PLANT QUARANTINE,
U. S. DEPARTMENT OF AGRICULTURE,
BELTSVILLE, MD.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AN ADJUSTABLE RESISTANCE WITH LINEAR RESPONSE TO AIR FLOW FOR RESPIRATION EXPERIMENTS

IT is often necessary in respiration experiments and clinical work to apply resistance to inspiration or expiration. It is desirable to have this resistance increase linearly with increasing air flow as Davies, Haldane and Priestley[1] have pointed out. The value of such a characteristic is that it represents the change in resistance produced in humans in diseases such as asthma and bronchitis. It is also the type of resistance applied to man by protective respiratory devices such as gas masks and respirators. Davies *et al.* have used canisters filled with cotton wool to give linear response to inspiratory resistances. Obviously, such resistances are not suitable for expiratory resistances because moisture will wet the wool and alter the resistance. Killick[2] has used a pair of flanged inverted funnels with filter papers clamped between them for inspiratory resistances and these also yield a linear response. We[3] have used the same type of funnels but with a glass filter cloth placed between the funnels. By heating the funnels with an electric heating element they may be used for inspiratory and expiratory resistances without interference of moisture absorption or condensation.

Several investigators, principally Hill,[4] Matthes[5] and Barach,[6] have used orifices of varying sizes for introducing resistance to respiration. The resistance to air flow of an orifice varies nearly as the square of the flow or parabolically, hence a doubling of flow increases the resistance fourfold. The use of varying sizes of orifices for adjustable resistance is not entirely satisfactory because of this parabolic flow-resistance relationship. For our experiments a linear response was desired and changes were to be made during the experiment by gradual increase (occasionally decrease) of resistance while the subject was sedentary or exercising. It was not practicable to add layers of glass filter cloth to funnel devices in place or change to different funnel devices because of the time and manipulation necessary.

Flow-measuring instruments[7] were placed in the inspiratory and expiratory tubes thus making it impractical to remove and insert different resistances without the subject's knowledge while an experiment was in progress.

The apparatus described here gives linear resistance response with air flow and is adjustable in resistance from 0.1 to 1.0 mm of water per liter of air flow per minute.

DESCRIPTION OF APPARATUS

A diagrammatic sketch of the apparatus is shown in Fig. 1. It consists of two concentric plastic tubes (lucite) with an annular space between them. The central tube is sectioned so that four supporting strips approximately 3 mm wide remain. A piece of glass filter cloth (WB–0048, Filter Media Corporation, New York) is wound cylindrically around this section and the edges are cemented to the lucite tube by means of

[1] H. W. Davies, J. S. Haldane and J. G. Priestley, *Jour. Physiol.*, 53: 60–69, 1919–20.
[2] E. M. Killick, *Jour. Physiol.*, 84: 162–172, 1935.
[3] Leslie Silverman. Unpublished data. 1943.
[4] L. Hill, *Jour. Physiol.*, 87: 17P–18P, 1936.
[5] H. V. Matthes, *Arbeitsphysiologie*, 11: 118–128, 1940.
[6] A. L. Barach, *New Eng. Jour. Med.*, 230: 216–233, February 24, 1944.
[7] L. Silverman, R. C. Lee and C. K. Drinker, *Jour. Clin. Invest.*, 1944.

Pyseal (Fisher Scientific Company). This cloth is approximately 19 × 12 cm and the center tube is 3.8 cm outside diameter, 3 mm wall thickness and 29.2 cm long. The outer tube is 6.4 cm outside diameter,

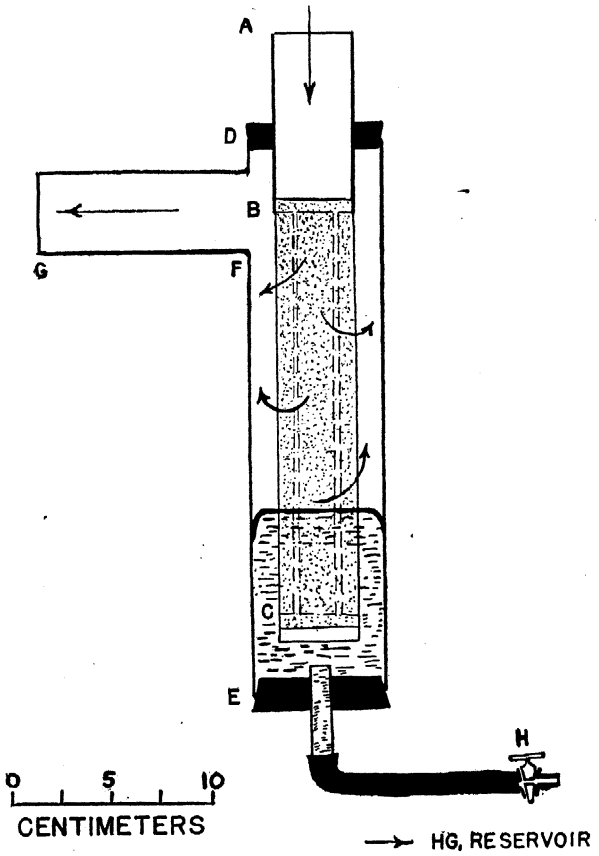

FIG. 1. Diagrammatic sketch of the linear response adjustable resistance. Air may enter either end although an air flow direction is indicated.

3 mm wall thickness and 33 cm long. An outlet tube of the same diameter as the inner tube completes the connections. An approximate scale is shown in Fig. 1. Mercury fills the annular space between the two tubes, and thus the amount of area of the cloth is increased or decreased. A paper millimeter scale is attached to the wall of the outer tube for reading the height of the mercury meniscus. Scale zero is approximately at C. The ends D and E are closed by rubber stoppers which are wired in place. The glass elbow in the lower stopper E connects with stopcock H and a mercury reservoir. Air enters the apparatus at A and leaves at G after passing through the filter cloth. The air can enter at G and leave at A if desired. When used on expiration a small heated section of tube precedes the resistance to prevent water condensation on the glass cloth. This is necessary if experiments continue for any length of time over fifteen minutes. Below that length of time the amount of water condensed does not appreciably affect the resistance of the cloth.

Mercury is used for an area adjusting medium because of its high specific gravity and surface tension. The amount of movement of the mercury column because of pressure differentials during breathing is not significant within the range of pressures shown in Fig. 2. A mechanical device can be made to reduce

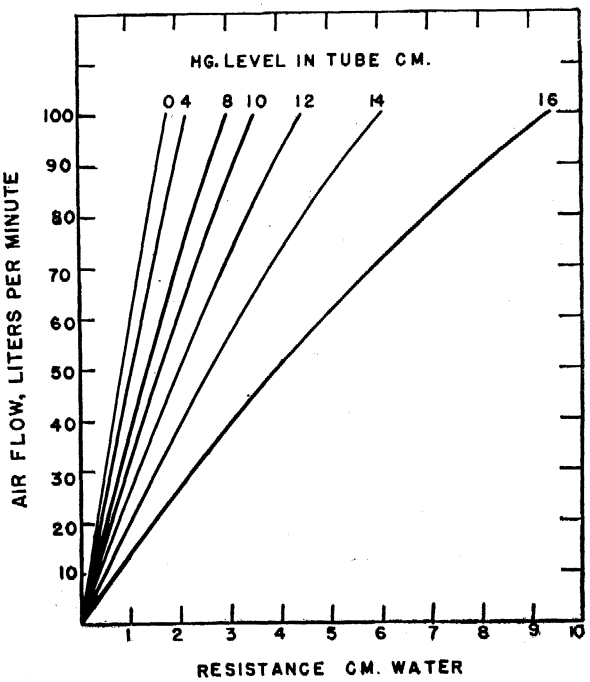

FIG. 2. Resistance-air flow response of apparatus with decreasing filter cloth area (adjusted by rising mercury column).

the area of the cloth and eliminate the mercury, but its construction would be complicated.

A typical calibration of one of the laboratory units is shown in Fig. 2. The resistance on suction was measured by a tap near the outlet G, while a bell mouth was placed at A to eliminate the entrance loss. Since the unit is usually used in series in a breathing line the bell mouth gives conditions corresponding to line resistance differentials. If the resistance is not preceded by other apparatus a bell mouth is desirable since it will eliminate the orifice loss and non-linearity of the inlet. On blowing this precaution was not necessary. With the bell mouth in place resistance values on suction and blowing agree closely. The resistance response shown in Fig. 2 indicates that the apparatus resistance is almost linear with air flow. Deviations begin to occur at high air flows (above 80 liters per minute) and when the area of the cloth is reduced to a small amount. In the latter case the deviation is caused by high velocity through the cloth causing departures from laminar flow through the

cloth openings. The departure at high flows is caused partially by the high velocity through the cloth and very slightly by the resistance loss of the tubing and the elbow loss at connection F. The amount of departure from linearity at zero mercury level is small, thus indicating that the tubing and orifice loss are negligible. The size of the apparatus can be changed to other dimensions for other purposes. If the tubing diameter is decreased the departure from linearity will occur at lower air flows.

One disadvantage to the use of the apparatus for inspiration is the presence of mercury for an area-adjusting medium. During expiration, of course, there is no significant mercury exposure. Measurements of the mercury vapor concentration were made with the General Electric mercury vapor detector.[8] Air was drawn through the tube at a rate of 25 liters per minute and readings were taken at several positions of the mercury level. The mean concentration indicated was 6 milligrams per 10 cubic meters of air. This value is six times the permissible exposure for an occupational exposure. The time of exposure in our experiments is less than one hour, whereas the threshold value of 1 milligram per 10 cubic meters is based on a daily exposure.[9] On this basis, therefore, the amount of mercury absorbed in one hour's exposure is less than the permissible daily absorption.

SUMMARY

A simple easily adjustable linear response resistance apparatus is described. The resistance unit contains a glass filter cloth, the effective area of which is adjusted by a mercury column.

The resistance of the unit can be adjusted from 0.1 to 1.0 millimeters of water per liter of air flow per minute. The resistance can be easily increased or decreased during the progress of an experiment. The mercury hazard during inspiration was evaluated and not found significant for experiments of one hour.

LESLIE SILVERMAN
M. N. RAO

DEPARTMENT OF INDUSTRIAL HYGIENE,
HARVARD SCHOOL OF PUBLIC HEALTH,
BOSTON, MASS.

THE DETECTION OF PENICILLINASE-PRODUCING PROPERTIES OF MICRO-ORGANISMS

IN quest of active penicillinase-producing organisms a simple method for the rapid determination of the ability of organisms to produce this penicillin-inactivating enzyme was evolved. Most previously used methods involve the assay of a penicillin solution before and after exposure to the inactivating substance.

This method is based on the ability of penicillinase to diffuse from the organism in question into a penicillin agar medium previously inoculated with a penicillin sensitive organism. The penicillin added to the medium is sufficient to inhibit the seeded sensitive organism so that no growth occurs. If a penicillinase-producing organism is streaked onto the surface of this medium, penicillinase is elaborated in its growth which diffuses into the agar, inactivates the penicillin and thus permits the seeded sensitive organism to grow out. The growth occurs as a stippled zone of satellite colonies around the streak. Details of the method are as follows:

To 10 cc of melted tryptose-phosphate agar at 45° C., 0.1 cc of a 24-hour broth culture of a sensitive *Staphylococcus aureus* (the strain used was sensitive to 0.04 units of penicillin per cc) is added. Penicillin solution is then added to give final concentrations of 0.5 units per cc. Plates are poured and allowed to harden at room temperature. A minimum of surface moisture is necessary. The organism under study is then introduced by a single streak. Several organisms may be tested simultaneously on the same plate provided sufficient space is allowed for ascertaining the zone of inactivation. Best results have been obtained by making the streaks from the center outward like the spokes of a wheel. The plates are incubated at 37° C. for 24 to 48 hours and inspected for satellite Staphylococcus colonies. If the streaked organism does not produce penicillinase, satellite Staphylococcus colonies are not observed. If the streaked organism produces sufficient penicillinase, satellite colonies of Staphylococcus occur around the line of the streaked organism. The width of the zone of satellite colonies will vary, depending on the amount of penicillinase produced and the concentration of the penicillin in the agar.

Rough quantitative determinations of the amount of penicillinase produced can be made by measuring the width of the zone of satellite growth. More accurate quantitative studies can be made by using a series of plates with varying penicillin concentrations.

This method can also be used for the primary isolation of penicillinase producing organisms. Poured or streaked plates of the sample containing the organisms are made with the seeded penicillin agar medium. Only those colonies that grow readily and produce a zone of satellite Staphylococcus colonies need be picked for further study.

JOSEPH S. GOTS,
Sanitary Corps, AUS

AAF REGIONAL STATION HOSPITAL,
DREW FIELD, FLA.

[8] T. T. Woodson, *Rev. Sci. Instruments*, 10: 308–311, 1939.

[9] American Standard: Allowable concentration of mercury. 37.8—1943. American Standards Association, New York. Approved January 6, 1943.