given to a patient with hypertensive heart disease accompanied by the characteristic changes in the electrocardiogram there was a reduction in voltage of the QRS deflections which persisted for several hours. Frequently there was also a reduction in the length of the QRS interval. In the vast majority of cases the T-wave became less inverted or upright when it was originally inverted, or taller when it was originally upright. Serial electrocardiographic observations showed that following the administration of potassium the electrocardiogram passes in reverse order through the same series of configurations that it passes through in the course of the development of the changes characteristic of hypertensive heart disease. In a few instances the T-wave became more deeply inverted after potassium even though the voltage of the QRS deflections was reduced. In the majority of instances the mean axis of the QRS shifted to the right of its original position while that of the T-wave was shifted to the left. The magnitude of the ventricular gradient was usually increased and its direction was shifted slightly to the right.

In normal subjects the administration of potassium was followed by electrocardiographic changes similar in character but less pronounced than those seen in cases of hypertension. In one patient with left ventricular enlargement due to luetic aortic insufficiency, but with no definite increase in blood pressure, the administration of potassium was followed by pronounced toxic symptoms and transient left bundle branch block.

In hypertensive vascular disease sodium restriction alone is followed by electrocardiographic changes identical with those produced by the administration of potassium. No close correlation between the changes in blood pressure and the changes in the electrocardiogram is apparent. It should be pointed out that the electrocardiographic changes following sympathectomy in hypertensive patients are of the same type, and, that in this case also these changes are not always very closely related to the effects on the blood pressure.

In calling attention to the similarity between the changes in the electrocardiogram produced by the administration of potassium in cases of hypertensive heart disease, and the changes in the electrocardiogram which often follow sympathectomy or the restriction of sodium in cases of the same kind, we do not imply that the mechanism by which these electrocardiographic changes is brought about is necessarily the same in both instances. This is a question which can be decided only by future investigations.

The potassium dibasic phosphate used in this study was supplied through the generosity of Parke, Davis and Company.

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A Gaseous Nitrogen Elimination Test to Determine Pulmonary Efficiency.

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Nearly all physiologists interested in respiration have contributed to our knowledge of nitrogen elimination produced by decompression or by oxygen inhalation. As space prevents an adequate review of the literature, we can only refer the reader to typical references of studies by Haldane and Priestley,[1]

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1 Haldane, J. S., and Priestley, J. G., *Respiration*, New Haven, Yale University Press, 1935, 493 pp.

2 Berggren, S. M., *Acta physiol. Scandinav.*, 1942, **4** (Suppl. **11**).

Berggren,[2] Behnke,[3] Bornstein,[4] Lundsgaard and Van Slyke,[5] Christie,[6] Cournand and his associates,[7] and Bateman.[8]

As a result of the ease and rapidity of analysis possible with the nitrogen meter devised by Lilly and Anderson[9] of the Johnson Foundation it is now possible to make, as frequently as desired, readings of the nitrogen content of oxygen-nitrogen mixtures. For the principle and details of this nitrogen analyzer the reader should consult the original paper. For our use Baldes enlarged the lower part of the scale (0 to 15%) so that differences in the nitrogen content of CO_2-free nitrogen-oxygen mixtures at constant temperature and saturated with water vapor can be determined with an accuracy of 0.05% points provided duplicate analyses in Haldane high oxygen gas-analyzers are made at the beginning and end of each experiment for the purpose of calibration; the intermediate readings are linear.

The respiratory apparatus used is a closed circuit system consisting of a spirometer, soda-lime container, filter and a blower with corrugated tube connections to the valve attached to mask or mouthpiece.

The spirometer records both respiratory movements and ventilation rate and has a fan on the floor for rapid mixing of gases. For an experiment it is filled with 40 to 60 liters of oxygen (99.6 $\pm$ 0.1% purity) so that at the end of the 30-minute experiment the nitrogen content does not exceed 8 to 10%. Wet and dry bulb thermometers are placed in the air stream just as the circulating mixture leaves the gasometer. A sampling tube leads to the nitrogen meter which draws out approximately 6 cc per minute. The blower produces a flow of 80 to 100 liters per minute through the closed circuit system. Therefore the over-all time lag is less than 0.2 minute from the moment the expired air enters the system to the meter reading of the nitrogen content of the mixed gases.

The experiment itself is conducted like a basal metabolism test except that it lasts 30 minutes. The valve to start the experiment must be turned exactly at the bottom of the subject's natural expiration to avoid a bothersome correction. Just before the experiment is ended the vital capacity is determined by 2 cycles of maximal inspiration and expiration; the spirometer tracing is then continued for 5 minutes to establish accurately the average expiratory level from which the different pulmonary subdivisions are calculated.

The accumulated nitrogen elimination (BTPS) is a simple calculation and should be made for 15 to 20 different points in the 30 minute experimental period. For plotting we have found the use of 2 by 3 cycle log-log paper very convenient, for the following reasons: 1. The time scale covers 3 log units (0.2 to 30 minutes). 2. As first shown by the experiments of Boothby, Lovelace and Benson,[10,11] the body tissue nitrogen, both when the subject is at rest and when he is at work, when accumulated and plotted on log-log paper forms straight lines for more than 200 minutes; the slope of the line is in the main dependent on the rate at which the venous blood returns to the lungs. 3. The accumulated nitrogen coming from the air in the lungs rises very rapidly from the beginning of the experiment; when the pulmonary nitrogen has been completely eliminated, a sharp angle or knee is made as the further

[3] Behnke, A. R., *U. S. Naval Med. Bull.*, 1937, **35**, 219.

[4] Bornstein, A., *Z. f. exp. Path. u. Therap.*, 1918, **20**, 495.

[5] Lundsgaard, Christen, and Van Slyke, D. D., *J. Exp. Med.*, 1918, **27**, 65.

[6] Christie, R. V., *J. Clin. Invest.*, 1932, **11**, 1099.

[7] Cournand, Andre, Baldwin, Eleanor deF., Darling, R. C., and Richards, D. W., Jr., *J. Clin. Invest.*, 1941, **20**, 681.

[8] Bateman, J. B., *Proc. Staff Meet., Mayo Clin.*, 1946, **21**, 112.

[9] Lilly, J. C., and Anderson, T. F., National Research Council, Division of Medical Science, CAM Report No. 299, 1944.

[10] Boothby, W. M., Lovelace, W. R., II, and Benson, O. O., *J. Aeronautical Sci.*, 1940, **7**, 524.

[11] *Physiology of Flight; Human Factors in the Operation of Military Aircraft.* A compendium of lectures and demonstrations given to Army Air Force personnel. The Aero Medical Research Laboratory, Experimental Engineering Section, Materiel Center, Wright Field, Dayton, Ohio, 1940-1942, p. 27, Fig. 15.

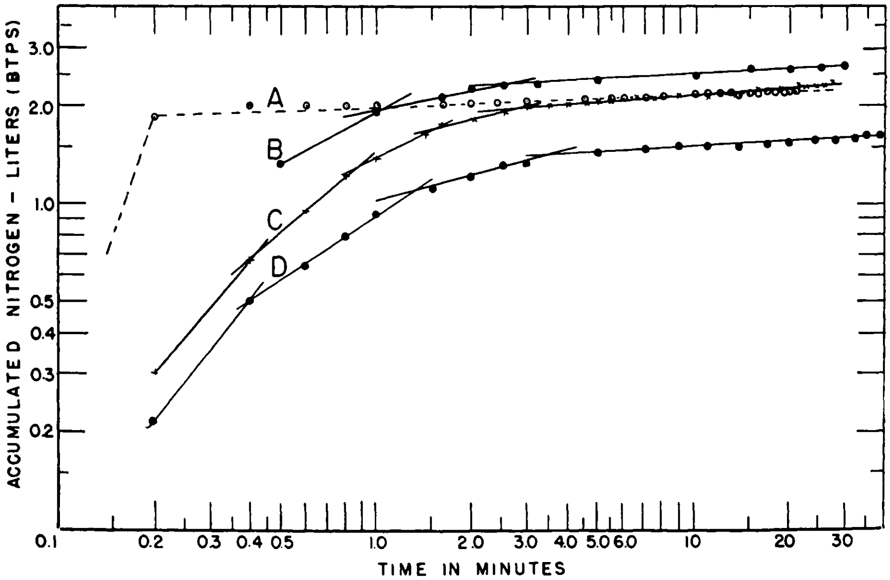

FIG. 1.

Characteristic curves plotted on log-log paper. Subject: man, aged 37 years; height 183 cm; weight 83.6 kg; surface area 2.07 square meters.

A. Subject started with 4 maximal respirations, then breathed normally.
B. The largest value for functional residual air volume in the series. Normal breathing.
C. The usual value for functional residual air volume in the series. Normal breathing.
D. The smallest value for functional residual air volume in the series. Normal breathing.
In B, C, and D the nitrogen washout time was between 2½ and 3½ minutes.
In A the washout time with 4 deep breaths was 0.2 minute.

accumulation of tissue nitrogen begins to form the straight line that continues for the duration of the experiment. The first part of the curve, representing essentially pulmonary nitrogen, may be in 2 or sometimes 3 phases which are important indicators of the degree and cause of respiratory inefficiency in some pulmonary diseases. 4. The final and characteristic bend or knee in the nitrogen elimination curve on log-log paper serves therefore as a convenient method of separating pulmonary from tissue nitrogen (Fig. 1). This graphic method permits one also to estimate, when desired, the comparatively small amount of tissue nitrogen that is eliminated along with the pulmonary nitrogen.

To calculate the functional residual air volume (BTPS) first read from the log-log plot the volume of nitrogen corresponding to the final bend or knee; second, divide this volume by the usual fraction of nitrogen normally present in alveolar air, 0.80, less the fraction of nitrogen in the inspired air at the time this knee is formed (which is usually about 0.05). The true residual air volume is obtained by subtracting the supplementary (reserve) air volume; the complementary and supplementary air volumes, the sum of which is the vital capacity, are obtained from the spirometer respiratory curve; the mean expiratory level is the base line from which the measurements are made. The total capacity is the vital capacity plus the true residual air volume. All air volumes are expressed at body temperature and pressure, saturated with water vapor (BTPS). They therefore represent the true size of the lung space available for respiration.

The oxygen consumption is determined as in any closed circuit system (after proper corrections) from the decrease in the spirometer volume during the experimental period.

The ventilation rate is also read from the spirometer tracing and the ratio between oxygen consumption and ventilation rate is calculated.

The efficiency of the subject's natural method of breathing is determined by the

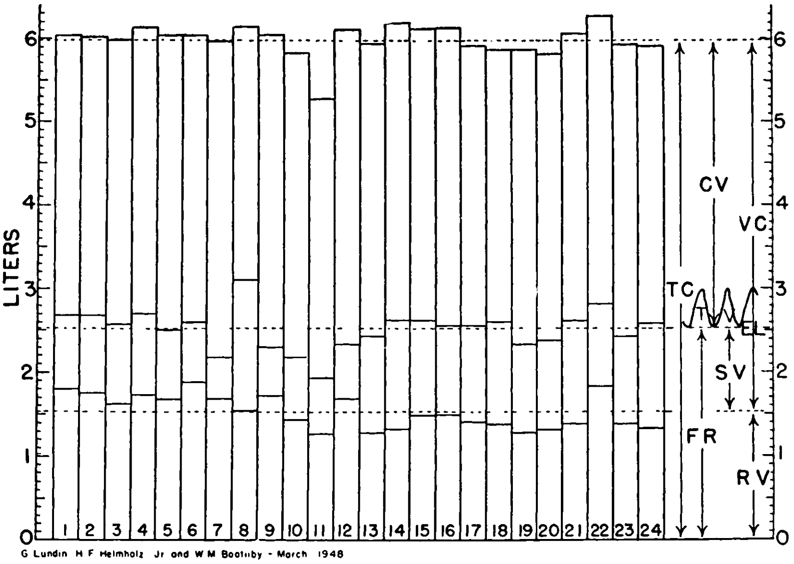

FIG. 2.
Variations in the subdivisions of lung capacity as found in a series of 24 experiments on a normal subject at rest in a sitting posture. Subject: man, aged 37 years; height 183 cm; weight 83.6 kg; surface area 2.07 square meters. TC—total capacity; FR—functional residual air volume; CV—complementary air volume; SV—supplementary air volume; VC—vital capacity; RV—true residual air volume.

washout time required for elimination of the nitrogen that was in the pulmonary air; that is, the time after the subject begins breathing oxygen to the point on the plot where the knee or final bend occurs. In normal subjects under basal conditions this varies between 2 and 3.5 minutes; ventilatory inefficiency is increasingly severe as the washout time increases beyond 4 minutes; some patients with marked emphysema require 10 to 12 minutes to clear their lungs of pulmonary air nitrogen. In a normal subject under the same conditions the results are reproducible, as seen in Fig. 2.

Summary. An improved method for determining the nitrogen washout time with measurement of the various subdivisions of the pulmonary volume is described. The method is proving helpful in the differential diagnosis of pulmonary disease and in estimating the functional changes produced by intrathoracic operations.