Third. The amount of actual loss in acuity of hearing was not proportionate to the loudness of the tinnitus. After hearing returned to normal the tinnitus continued for at least twenty-four hours.

Fourth. A tinnitus produced by a continued loud sound gives rise to similar sensations of fullness in the ears and does not bear any definite pitch relation to the frequency of the sound causing the condition. The acuity of hearing was not impaired after three and one half hours exposure.

Fifth. Recovery of normal hearing after ingestion of quinine occurs in 24 to 36 hours.

Sixth. The toxic affect of quinine influence not only the auditory sense, but the entire nervous apparatus is affected so that definite readings with larger doses are not possible.

Seventh. We present herewith a study in the application of modern methods in the measurement of acuity of hearing. The disadvantages shown in this accurate method practically rule out the watch tick tick and the tuning for K tests in their application to minimum audibility.

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Studies on lung volume. IV. Investigations on admixture of air in the lungs with other air.

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Several methods of importance for the study of the physiology and pathology of respiration and circulation require (1) that it is possible to produce full admixture of air within the lungs with other air and (2) that the exact conditions necessary for full mixture can be ascertained in a given case. This and the following paper is a short report of experiments dealing with questions.

Technique. 3 liters of oxygen (Allen-Pepys' method) or of hydrogen plus oxygen (Davy-Durig's method) are introduced in a 5 to 6 liter rubber bag. Starting either from full inspiration or full expiration the subject rebreathes uniformly and almost as deeply as possible from the bag a certain number of times. The connection between the mouth and the bag is a 35 cm. long, 2 cm. wide rubber tube and a 3-way stopcock. The frequency of respiration has always been betwen 8 and 20, usually about 10-15 per minute. During the experiments several small samples (15-20 c. c.) of air were drawn (1) from the bag, and (2) from the very last part of the expiration. In the last instance therefore, alveolar air was obtained. The samples were drawn into evacuated recipients without interrupting or interfering with the breathing. By such a procedure (Fig. 1) one can follow the changes in the composition of the air in the two most important places (bag and alveoli) of the closed system during the rebreathing experiment. In the oxygen experiments the changes in the nitrogen percentage were followed and in the hydrogen experiments the changes in the hydrogen percentage were observed.

Results. In Table I an example of oxygen experiments are given and in Table II an example of hydrogen experiments. Figs. 2 and 3 correspond to Tables I and II respectively.

If complete mixture is defined as a state of uniformity of composition of air in the whole rebreathing system, it is already clear that full mixture cannot be obtained on account of the continuous interchange between the alveolar air and the blood gases, (the influence of respiratory quotient, of hydrogen absorption

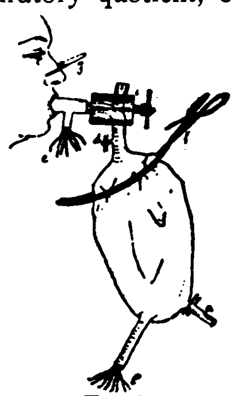

FIG. 1

Five liters rubber bag. Lead tubes with capillary borings for drawing samples without interfering with rebreathing.

and of nitrogen loss by blood). If, on the other hand, complete mixture is defined as the condition where the initial difference between bag air and lung air has disappeared then it is, as our experiments show, possible to obtain such a mixture. An analysis in Table I and Fig. 2 shows that the point of full mix-

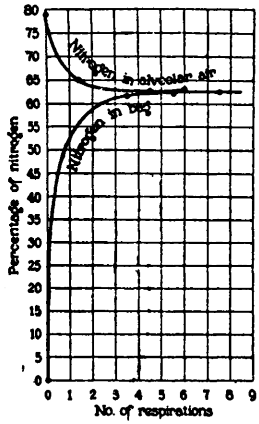

FIG. 2

Mixing curves obtained by taking repeated samples of air from bag (lower curve) and from alveoli (upper curve).

ture is reached when the upper curve is at its lowest point. If rebreathing is continued a steady slight increase in the nitrogen percentage of bag and alveolar air is seen. This is due to the interchange between blood gases and alveolar and can not be overcome by prolonging the experiment. On the contrary, if the rebreathing is continued longer than necessary, the inevitable error due to the alveolar interchange increases. The point of full mixture is therefore indicated by the lowest point of the alveolar curve, and the value for the nitrogen percentage which is most correct is the corresponding point of the lower curve.

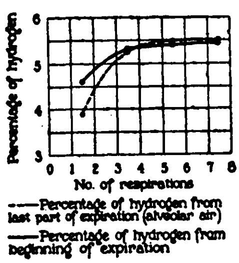

FIG. 3

Mixing curves from hydrogen experiment. Samples taken at the first part (———) and the last part (– – –) of the experiment. Crossing of curves indicates mixture.

In hydrogen experiments similar conditions are obtained if the percentage of oxygen is not too low (table 2, Fig. 3). The two curves cross each other and continue a parallel, slightly upward course. The point which indicates admixture is indicated by the intersection of the two curves. The hydrogen percentage at this point should therefore be used as indicating the percentage in the system at the time of admixture. Our experiments were performed on normal individuals, on emphysematic patients and on one patient with mitral insufficiency. None of the subjects had a vital capacity below 2 liters and a residual air above 2½ liters. In all cases a mixture was obtained between after from 2 to 6 respirations usually after 3 respirations. The error due to the interchanges between alveolar air and blood gases is as a whole not large. It increases with the duration of the experiment and with the degree of difference in tension of the gases in the alveolar air and the blood gases.

TABLE I.

Analyses of samples of air from bag and from alveoli drawn during one rebreathing oxygen experiment.

Number of respiration at which sample is drawn.	Alveolar air.		Air from bag.	
	Nitrogen. per cent.	Carbon-dioxide. per cent.	Nitrogen. per cent.	Carbon-dioxide. per cent.
1½	64.88	4.39	....	....
2½	....	....	....	....
3½	....	....	61.72	4.49
4½	62.46	4.87	....	....
5½	62.61	5.17	62.19	5.10
6½	....	....	....	....
7½	....	....	62.72	5.75

TABLE II.

Hydrogen experiment. Analyses of samples of air from the first and the very last part of the expiration. The samples are drawn into evacuated recipients.

Number of respiration at which sample is drawn.	Percentage of hydrogen in the first part of an expiration.	Percentage of hydrogen in the very last part of an expiration.
1½	4.62	3.90
3½	5.34	5.30
5½	5.44	5.48
7½	5.48	5.52