NORMAL HEARING BY BONE CONDUCTION

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THE limits of normal hearing by bone conduction must be known before any given finding can be accurately described as abnormal. The work described in this paper was carried out to ascertain the normal range, concerning which there is no published data, on a large number of young healthy adults whose hearing has been measured in a silent room with an audiometer.

The Subjects.

Medical students from University College volunteered to be tested. One hundred people (seventy-four males and twenty-six females) were chosen all between the ages of 18 and 25 years, and who had never had any ear disease.

The Test Room.

The investigation was conducted in the sound-testing room of the Royal Ear Hospital. This room is 22 by 10 by 8 feet and is constructed with an outer shell of 9 inch brickwork with a concrete floor, inside which there is a framed timber box forming the Silence Room. This box is carried on the concrete floor, and has no contact with the outer brickwork shell or floor above. This inner timber shell has, therefore, an air space of about 5 inches extending all around the walls and ceiling. All the inner surfaces of the outer shell are covered with a lining of cabot quilting (a sound-deadening material made from seaweeds). The outer and inner surfaces of the inner timber shell are covered with the same material and finally, the inside walls and ceiling of the Silence Room itself are plastered with Sabanite, a porous acoustic plaster.

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There are double entrance doors with felt-lined rebated frames and each door is cork-lined on both sides. In spite of this special construction the room is not completely sound-proof, and the ears of the subjects were stopped with cotton wool as an additional precaution.

The Audiometers.

Determinations of the threshold of hearing by bone conduction were made, using two audiometers made by the Western Electric Company, one an American battery model (type 2B, the property of the Medical Research Council), the other an English mains instrument (type 2BE, belonging to the Royal Ear Hospital). The calibrations of both were checked by the firm shortly before the investigation was undertaken. The bone conductor receiver was type D80904 in both cases.

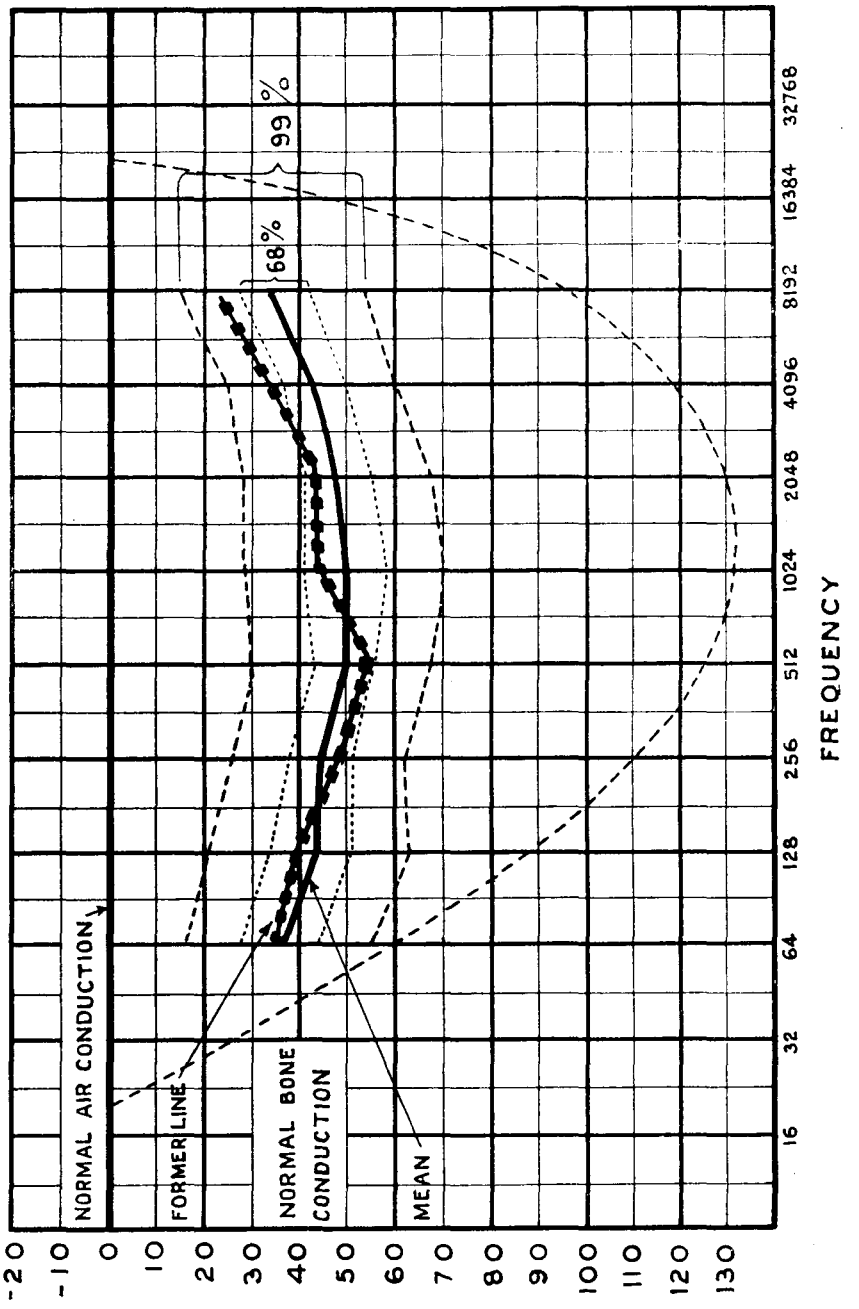
The Test.

The nature of the test was explained to the subject, who was then given the bone conductor receiver and asked to place it over his mastoid bone. A tone of 256 cycles per second at maximum intensity was then switched on, and the subject was asked to move the earpiece to various places over the bone to find the place at which he could hear it loudest. Some people can hear at one point on the mastoid bone much more acutely than at other points. This optimum position has been attributed to resonance in the mastoid antrum. The important consideration is that a good position should be found and kept to throughout the series of tests.

It might be argued that it would have been a more scientific measure of the auditory threshold if this position of more acute hearing had been avoided. But as a bone conduction test result is commonly used as an indication of the possible success of a bone conduction hearing aid, the above practice was adopted.

The test tones were of frequencies 64 to 8,192 cycles per second in octave steps. Readings of the threshold were taken with a descending intensity of sound and an increasing intensity, and a mean of the two observations at each pitch taken. Confusion between feeling and hearing of the lowest two test tones was easily avoided after explanation. The tests were not repeated, so as to avoid auditory fatigue, and because it is not usual to do so under clinical conditions. The test results were

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recorded by two of us (A.G. and E.J.R.) each of whom used one audiometer for half the cases, and the other for the remainder.

The Results.

The results have been summarized in the accompanying figure, which also shows as a line with squared rectangles the level for " normal bone conduction " which is given in the instruction bulletin of the Western Electric audiometers. No data concerning the way in which this level was ascertained is usually given, but on enquiry a private communication was received stating that " this characteristic was arrived at on the basis of tests made on thirty young adults, about equally divided between male and female, and having normal hearing ".

It will be seen that the mean values found in the present series are not very different from those given by the Western Electric Company. The new curve is smoother, probably because more subjects were tested in the present work.

The actual mean values and the standard deviations therefrom are given in the following table.

TABLE I.

Bone Conduction Hearing Threshold of 200 *Normal Ears, expressed as the mean difference from the normal air conduction hearing threshold in decibels. The standard deviations from the means are also given.*

Pitch.	Left ear.		Right ear.		Both ears.	
	Mean.	S.D.	Mean.	S.D.	Mean.	S.D.
64	36·5	6·7	36·5	6·9	36·5	6·8
128	42·0	7·7	41·5	7·8	41·75	7·95
256	45·75	6·0	45·0	6·7	45·0	6·5
512	49·75	7·5	49·5	7·4	49·5	7·4
1,024	50·0	8·3	50·0	8·0	50·0	8·2
2,048	48·5	6·7	48·0	6·8	48·5	6·8
4,096	44·0	7·45	43·0	7·0	43·5	7·1
8,192	33·5	6·95	34·0	6·2	34·0	7·0

Rough plotting of the individual observations suggested that the assumption was justified that the variations about the mean at any given point can be represented by a Gaussian curve. Using this assumption it was possible to construct the two belts shown within which one may expect 68 per cent. and 99 per cent. of the observations respectively to lie. The belts are

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actually constructed by calculating 1·00 and 2·5758 times the standard deviation respectively. There was no significant difference between the acuity of right and left ears. The authors are grateful to Dr. F. N. David, Lecturer in Statistics at University College, for help in planning the research and in the presentation of the results.

Conclusion.

The results show a somewhat wide variation, even though the tests were carefully done on intelligent and co-operating adults in a silence room. It is impossible to say how much of the wide range is due to differences in acuity of perception in the inner ear, and how much to differences in the ease of conduction from the skin over the mastoid through the bone to the inner ear. The results emphasize the fallacy of labelling bone conduction as abnormal when a determination on a patient is compared to a measurement on a single " normal " individual.

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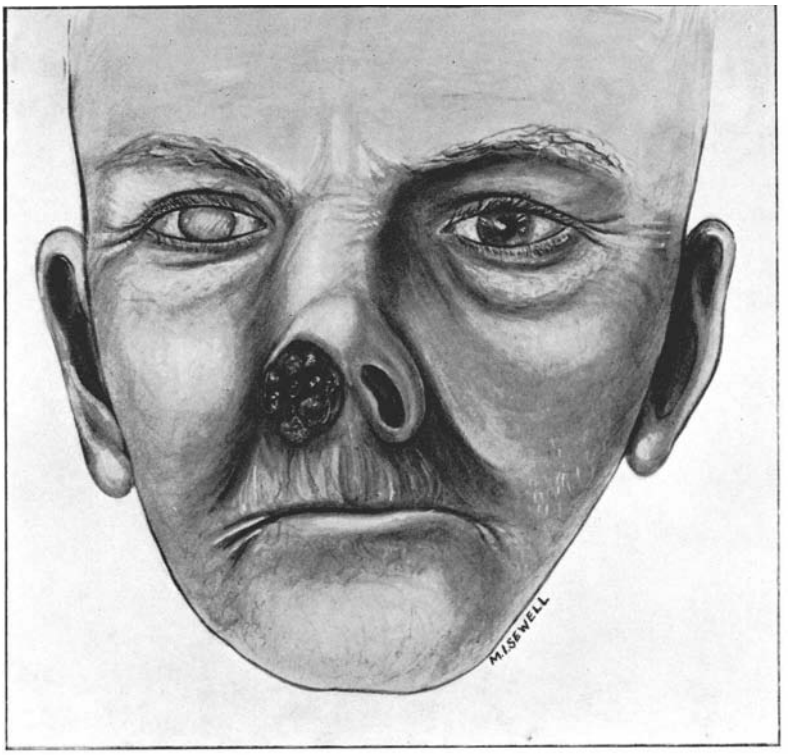


Fig. 1.

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