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Selection of Hearing Aids

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Selection of Hearing Aids

Edith L. R. Corliss

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Preface

For several years the National Bureau of Standards has been active in studying the properties of hearing aids. To aid in answering inquiries on the selection of such devices, a mimeographed leaflet (NBS Letter Circular LC945) was issued in 1949. The present Circular is based on LC945 and has been prepared to meet the increasing demand for information on hearing aids and related topics.

This Circular is intended primarily to assist a person in selecting a hearing aid for his own use. However, it also contains information which should be of interest to teachers and others wishing to explore this field.

The Bureau wishes to acknowledge the assistance and suggestions provided by the National Research Council's Committee on Hearing, the Volta Bureau, the American Hearing Society, the Audiology and Speech Correction Center at Walter Reed Hospital, and many interested individuals.

E. U. Condon, *Director.*

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Selection of Hearing Aids

By Edith L. R. Corliss

1. Introduction

Loss of hearing creates a serious problem. For most of us, the spoken word is our most important channel of communication. Even slight losses can interfere with participation in public affairs, and it does not take a very high degree of loss to hamper a person in conversation within a group.

Most individuals who have difficulty in hearing speech in a group conversation will find that wearing a hearing aid makes it easier for them to carry on their daily affairs. In addition, many people who have difficulty only with faint speech may be considered as "marginal" hearing aid users. These are the individuals whose hearing loss hinders them in public places—at lectures, meetings, and the theater. A simple inexpensive hearing aid would be of decided assistance to them. The instrument need not be very powerful. On the other hand, because persons with a slight loss can make direct comparisons between their unaided hearing and that with an instrument, they tend to be quite critical of the acoustic qualities of the hearing aid.

A person in need of a hearing aid has a special problem, for he himself must decide which instrument gives him the greatest benefit. Hearing aids cannot at present be fitted to individual hearing losses with the same exactitude as eyeglasses can be fitted to the refractive imperfections of the eye. A loss in hearing can occur either because the auditory nerve has become insensitive or because the sound vibrations are conducted inefficiently from the outer to the inner ear. Each of these conditions produces a hearing loss that behaves in a distinctive manner. Loss of hearing is often due to a combination of these causes in various proportions; it is not easy to measure the proportions. Therefore, the effectiveness of a hearing aid with known physical characteristics can be predicted only in a general way. The user must therefore pay close attention to the selection of his own hearing aid if he wishes to be well fitted.

Sections 3, 4, 5, and 6 describe the important properties of hearing aids, some of the criteria for judging them, and recommendations for their special care. To judge a hearing aid and to understand its limitations, it is helpful to consider the properties of sound and hearing that influence the performance of hearing aids. Section 2 contains a brief sketch of this background.

2. Some Properties of Sound and Hearing

The origin of the sensation of hearing is always some kind of energy. The most usual path through which hearing is stimulated starts with periodic pulsations of pressure in the air around us. These pulsations of pressure enter the outer ear and travel down the ear canal. They induce a to- and-fro motion of the eardrum. Attached to the inner side of the eardrum is a little chain of bones, so anchored that they take the relatively free flexible movement of the eardrum and convert it to small but very stiff motions of the fluid that fills the inner ear, or cochlea. (Cochlea is the Latin word for "snail"; the fluid chamber in the inner ear is coiled into a tight little spiral.) Within the cochlea, the ends of the auditory nerve protrude into the fluid that fills it. The periodic motion of the fluid past the nerve endings stimulates electrical alternations in the nerve. The signal ultimately reaching the brain is electrical.

Experiments have been made in which electrical signals applied to electrodes on the head produce the sensation of hearing. The conditions under which this can be done are so special that the method is not at present adaptable for hearing aids. However, these experiments do show that the ear must translate sound pulses into electrical energy. On animals, it has been possible to measure the electrical signals sent out by the inner ear to the brain when ordinary air-borne sound is applied to the ear. In the type of hearing loss called a "nerve" loss, either the inner ear mechanism no longer converts the motion of the fluid efficiently into electrical energy, or the auditory nerve simply does not carry the electrical signals to the brain. An interesting and mystifying quality of nerve loss is that it often acts as though a steep barrier had been placed in the path of hearing. Sounds that have enough energy to override the barrier may appear almost as loud to the person having a nerve loss as they do to a person with normal hearing. Doctors call this effect "recruitment".

If the eardrum or the bones in the middle ear are defective, they are unable to move the fluid in the inner ear very efficiently. The resulting impairment in hearing is called "middle-ear", or "conductive", loss, because the bones in the ear do not conduct sound very well. A person having this type of loss can use two alternative types of hearing aids. He can use a hearing aid that will supply sound pulses with increased power to his eardrum, so that even though the middle-ear mechanism is defective, the fluid in the inner ear is set into sufficient motion. Another type of hearing aid by-passes the ear bones altogether. It moves the bones of the skull by means of a vibration device, called a "bone conductor". The motion of the skull induces motion in the fluid of the inner ear, and the sensation of hearing is produced. As a rule, this bone conductor is not as efficient as an ordinary earphone, but it is used in special cases.

We are accustomed to hearing our own voices—in part, at least—through the bones of the head. The quality of the sound transmitted through the head is usually rather different from the sound transmitted through the air. As a result, phonograph recordings of our own voices sound strange to us, though each person can recognize his friends' voices from the recording. Because the sounds of their own voices reach them through the bones of the head rather than through the middle ear, persons with a "conductive" loss often have little difficulty in hearing themselves speak.

A tremendous range of energies will produce audible sound. The loudest sound to which the ear can be exposed without injury has about 1,000,000,000,000 times the energy of the faintest sound that can just be heard. Our experience tells us at once that the ear must use a scale different from that on which these numbers have been written down. The listener does not judge a very loud sound to be nearly a million million times as loud as the faintest sound he can hear.

The rate at which the sensation of loudness increases with sound energy is most nearly proportional, not to the total amount added, but to the size of the amount added in comparison to the sound energy already present before the addition was made. Everyone agrees that three violins playing together sound louder than one. Suppose you want to double that increase in loudness. It is necessary to persuade more than six violinists to play in unison—you need nine, each playing at the same intensity as the original player. Unless the solo violinist is playing very softly, the problem of producing a sound several times as loud soon exceeds the resources of a symphony orchestra.

The sense of hearing follows a scale that is widespread in nature. The same scale describes such diverse things as the rising of bread dough, the spread of epidemics, and the shape of sea shells.

In figure 1 (left) the curve of loudness is plotted against equal increases in sound energy. Notice that as you move to the right on the horizontal scale (increasing energy), the vertical distance representing increased loudness becomes smaller. To a close approximation, the increase in loudness is proportional to the ratio that the sound energy added bears to the total energy present. The scale that deals with increases proportional to the amount already present turns out to be a rather familiar one. Mathematicians call it a logarithmic scale. Loudness is therefore nearly proportional to the logarithm of the sound energy, and in estimating loudness the ear acts on a logarithmic scale. The relation of this scale to the ordinary number scale that we see on rulers and yardsticks—the "linear" scale—can be shown by a line drawn on a graph, as in figure 1 (right). In the horizontal direction, equal distances along the scale are proportional to the ordinary number scale. In the vertical direction, equal distances along the scale are proportional to the common logarithmic scale, which ex-

FIGURE 1. *As the curve at the left shows, if the energy of a sound is increased, the sensation of loudness perceived by a listener does not increase as rapidly as the increase in energy.*

The curve at the right shows that the logarithm of a number has much the same property. These curves show that the decibel scale, which is logarithmic, is directly related to loudness. The logarithmic scale is natural—as is shown by the profile of the sea shell (center). The animal must grow in such a way that it retains its shape, so that it continues to fit into the older part of its shell. Growth must therefore be distributed in proportion to the size of the creature already there, the shell thus forms a logarithmic curve.

presses the numbers in terms of the number of times (whole or fractional) that the base number 10 must be multiplied by itself in order to give the ordinary number. This curve has much the same profile as the loudness-energy graph.

Logarithms can be calculated for bases other than 10, and their properties are independent of the base chosen. Squaring the ordinary number always doubles the logarithm, and cubing triples it. The logarithmic scale agrees with our observation about the violinists no matter which number we choose for a base. However, the number 10 is most often selected as a base because it applies directly to the decimal system of ordinary numbers that we use in our daily life.

The roughly logarithmic relation between the loudness sensation and the sound energy is the reason that sound engineers adopt the decibel unit. The bel, which is equal to 10 decibels, was originally defined as the logarithm to the base 10 of the ratio of the energy put out by a system to the energy applied to its input. However, in dealing with hearing, it is used to express the ratio of the sound energy under discussion to the sound energy at the threshold of audibility. A change of 1 decibel in sound level is about the minimum difference that can be perceived by a careful listener. This amounts to a change of about 26 percent in energy.

Describing hearing loss in decibels gives the ratio between the least sound that a person can hear and the normal threshold. Thus, the sound that can just be heard by a person with a 20 decibel hearing loss has 100 times the energy of the sound at the threshold for a person with normal hearing; correspondingly, a hearing loss of 40 decibels means that the threshold energy required is 10,000 times as great as that for normal hearing. A scale of degrees of hearing loss in decibels is given in appendix 1.

In addition to loudness, we perceive two other properties in a sound: pitch and quality. Pitch is the word used to describe how low or how shrill a sound is. The sensation of sound is produced in our ears by periodic pulsations of pressure in the air around us. Although it is affected by loudness to some minor extent, the pitch of a sound depends primarily upon the rate at which the pulsations occur. This rate, the "frequency" of the sound, is usually expressed in cycles per second (i. e., the number of pulsations per second). Here, again, there is a logarithmic behavior in the ear, but in this case these logarithms must be expressed with the number 2 as a base. Doubling the frequency changes the pitch we perceive by what we recognize as one octave. To the ear there is as great an interval between 100 and 200 cycles per second as between 4,000 and 8,000 cycles per second—one octave in each case. The frequency range of pulsations giving rise to auditory sensation extends from 30 cycles per second to about 15,000 cycles per second.

From the quality of their sounds, we recognize at once the difference between a tin whistle and a flute. It turns out, upon investigation, that the sounds of a whistle, though of the same apparent pitch as those of a flute, have an admixture of pulsations of higher frequency than the base tone that determines the pitch. It is the composition of this mixture that we recognize as the quality of the sound.

There is a property related to sound that is often important in the consideration of hearing aids. That property is called "resonance." It describes the ease with which objects are set into sympathetic motion by the rhythmic pulsations of the sound. If the object has a natural mode of vibration (in which it would vibrate by itself if set off) that is of nearly the same frequency as the pulsations in the sound, it may vibrate strongly in sympathy with the sound. A system that is easily set into large motion at its natural frequency is described as "highly resonant." On the other hand, if energy is absorbed by friction, so that the sympathetic motions are limited in extent and duration, the system is said to be "damped."

3. General Properties of Hearing Aids

A hearing aid is simply a personal public-address system. It has a microphone to pick up sounds, a vacuum-tube amplifier to supply additional energy, and an earphone to transmit sound to the ear. Its performance is the result of a number of factors, some of them primarily related to the ear and the brain of the user.

A person with impaired hearing has the right to demand from a hearing aid something more than bare intelligibility. Actually, the brain is capable of piecing together an entire idea from mere fragments of speech sounds. As a result, an individual whose hearing loss is not severe can probably hear and understand speech with almost any hearing aid on the market. This does not mean that he will find it effortless or pleasant. However, at best he can describe the hearing-aid characteristics he desires only in a general manner, as a pleasing or "natural" quality of the transmitted sound. Or he may note that it is easier to hear through some hearing aids than it is through others.

The following discussion describes some of the characteristics of a hearing aid that are directly related to the "something more" in the relationship between the user and his hearing aid. It is only the listener himself who can determine which factor has the most weight in his particular case.

The "gain" of a hearing aid is its fundamental property. Gain represents the relative increase in power that a hearing aid produces in the sound it transmits. If there is a hearing loss, only a small fraction of the sound signal striking the unaided ear reaches the sensory organ in the brain. The hearing aid builds up the sound energy reaching the inner ear until it yields auditory sensation. The gain is a numerical measure of the extent to which the sound enegry is built up, or "amplified."

The gain of a hearing aid is not as a rule independent of the frequency (pitch) of the sound signal. However, if the instrument is to function as an aid, it must have a useful amount of gain for sound signals in the frequency range important for speech. These frequencies occupy the range between 30 and 15,000 cycles per second. Certain parts of this range are particularly important for the reproduction of speech sounds. The distribution of speech sounds, in frequency and sensation (loudness) level, is shown in figure 2. No sounds necessary for understanding speech occur in the frequency region below 200 cycles per second. As the figure shows, many consonant sounds will be suppressed by hearing aids that do not respond to sound in the upper part of the speech frequency range. The majority of the sounds that give speech its distinctive characteristics lie in the frequency range between 1,000 and 3,000 cycles per second. The older carbon hearing aids, dependent upon resonant microphone

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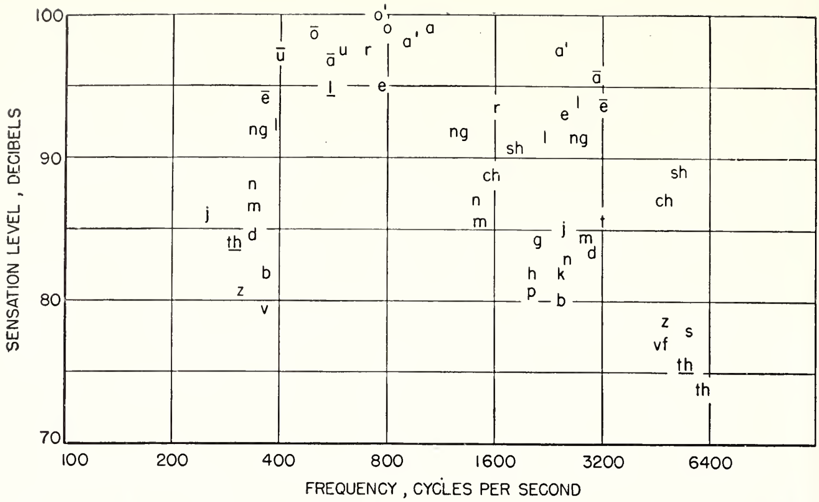

Figure 2. *This chart shows how the sounds that make up ordinary speech are distributed both in frequency and in relative loudness.*

For instance, we can see that the "d" sound has important frequencies around 350 cycles (vibrations) per second, and also around 3,000 cycles per second. Unless a hearing aid reproduces these frequencies, the d sound will not be clearly heard. The height of the d symbols in the chart shows that they are ordinarily spoken with medium loudness compared with other consonant sounds. (Chart from *Speech and Hearing*, by Harvey Fletcher of Bell Telephone Laboratories. D. Van Nostrand Co., Inc., New York, N. Y. Copyright 1929.)

and receiver diaphragms to increase their efficiency, were tuned to favor this frequency range. With these instruments, speech can be understood, but many individual vowels and consonants will not be clearly identified.

The curves shown in figure 3 are acoustic gain curves measured on two representative makes of hearing aids. Some idea of how speech sounds through them can be obtained by considering what it would be like if the gain curves were traced over the syllable chart in figure 2. The hearing loss of the user is, however, an additional factor involved in the performance of a hearing aid in service.

Ideally, a person using a hearing aid should hear sounds with the same loudness and tone quality as those heard by a listener with unimpaired hearing. In practice, quite a few compromises must be made. A hearing aid cannot provide hearing where the auditory nerve is inactive: it can only amplify sounds for which the user has some auditory nerve perception, however insensitive. In some cases of nerve impairment, sounds when heard at all are perceived to be loud. They may appear as loud to the person with nerve loss as they do to an individual with no hearing loss. But a person who has a hearing loss must wear a hearing aid to enable him to hear sounds he could not hear without the aid. When the sound is amplified to a high level, the intense sound put out by his hearing aid may be intolerably loud to the person suffering from nerve loss, and he may choose to do without the aid.

A listener recognizes large variations of the hearing aid gain with frequency as a "distortion" in the transmitted sound. This is truly a distortion, for if the gain does not provide uniform compensation for hearing loss over a fairly wide range of frequencies, only a poor

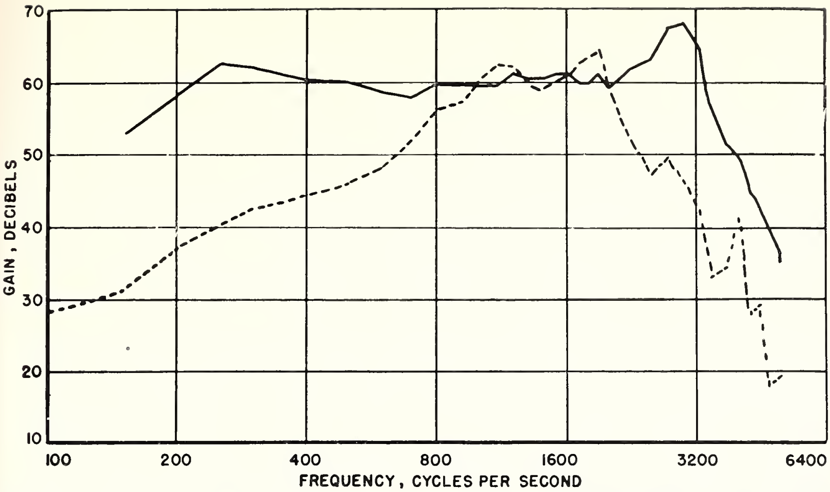

FIGURE 3. *These curves show the acoustic gain, or amplification, of two individual hearing aids.*

The instruments were of representative makes. Amplification of the two instruments is about the same in the middle frequency range, but differs considerably at higher and lower frequencies. A person selecting a hearing aid may have to try several instruments to find one that is satisfactory for his particular hearing loss.

replica of the sound finally reaches the auditor. This type of distortion is commonly called frequency distortion, because it results from inadequate frequency range or from too-sharp variations of gain with frequency.

Another type of distortion may have serious effects upon the sound transmitted by the hearing aid: when the incident sound level is too high for the power handling capacity of the hearing aid, the excess sound energy is converted by the overloaded instrument into sounds of extraneous frequencies. Overload distortion appears to a listener as a noisy blurring of loud speech sounds.

Both frequency and overload distortion in a hearing aid result from the compromises made in order to satisfy the demands for compactness and economy. Some hearing aids are built with microphones and earphones tuned to resonate in the middle of the speech frequency range. This is done to gain battery economy at the expense of uniform amplification, since uniform amplification over a wide frequency range is attained by heavily damping the natural resonances of the microphone and receiver, thus reducing their efficiency. Speech transmitted over a resonant system may sound tinny, but it will probably be intelligible.

In the quest for reduction in size, the "B" battery voltage has been continually decreased. When vacuum tubes are operated at lower voltages they cannot handle as large a signal without overloading. Fortunately, it happens that the reduction in size of the tubes themselves tends to minimize this effect. Earphones have generally less power-handling capacity when their size is small, but the demands for comfort and inconspicuousness sometimes result in the use of receivers that overload at output levels met with in ordinary use. This is especially undesirable because overloading due to small size is most likely to occur at the lower frequencies, introducing overtones in the output sound that blur the sounds of higher frequencies so important for the recognition of words.

Even though great care may be put into the engineering of a hearing aid, a poorly fitting ear mold can nullify the manufacturer's efforts. The ear mold provides a speaking tube leading to the eardrum of the user from the earphone, which is worn at the entrance to the ear. If it is too loose, sound energy is lost through leakage. The sound energy escaping may be sufficient to reach the microphone of the hearing aid. When this happens, the hearing aid will "squeal" on loud sounds, and it may even squeal continuously.

4. How to Judge a Hearing Aid

In a general way, certain qualities of the sound transmitted to a user's ear by his hearing aid indicate how well his hearing is being compensated for loss. If, without reading lips, he can hear what is said but has some difficulty in recognizing which person is speaking to him, his aid provides insufficient compensation at low frequencies. If, on the other hand, he can recognize the speaker's voice but cannot tell what is being said, the aid does not offer enough compensation at high frequencies. If speech of low intensity is intelligible but loudly spoken words are blurred and noisy, the hearing aid is being used at amplifications greater than those for which it is designed. For higher amplification, it is preferable to use a more powerful instrument. An occasional person with nerve loss may notice this effect with all hearing aids. In this case, however, the distortion arises within his own ear rather than in the hearing aid.

However, blurring of loud sounds may also be noticed in a hearing aid in which some part is wearing out, or when the batteries become weak. If a hearing aid that has not previously overloaded on loud sounds begins to do so and the insertion of new batteries does not remedy the condition, it may be in need of repair.

Where components with natural resonances are present, the amplification is much greater in the immediate neighborhood of the resonant frequencies. As a result, sharp sounds such as heel clicks, drum beats, or typewriter tapping, acquire a musical ringing quality. Certain speech sounds will also be affected by the resonances and will be accompanied by a ringing overtone in the transmitted sound. This may affect the intelligibility of the transmitted speech. A hearing aid that affords uniform amplification over a wide frequency range will transmit sharp sounds with their unmusical and incisive character unaltered.

Because a hearing aid is usually worn on only one ear, directions from which sounds originate cannot be recognized. This increases difficulties with extraneous noises, since the listener cannot restrict his attention to sounds from a particular direction. Tone controls that are intended to reduce background noise usually operate by reducing the amplification for sounds of lower frequencies. As some speech sounds have characteristic frequencies in this range, the tone control may affect the ease with which speech sounds are heard. In an effort to develop some type of binaural hearing when a hearing aid is used, experiments are now being carried out at several laboratories on the use of two separate instruments. Whether this results in good directional discrimination has not been established.

A hearing aid cannot discriminate between pleasant and unpleasant sounds. Over the same range of frequencies in which desired sounds occur, there are many irritating noises that cannot be shut out. The screeching of a hinge and the scraping of a fingernail occupy the same frequency region as do the consonant sounds essential for the recognition of words. Moreover, what may be called the "annoyance factor" of sounds is greater at higher frequencies. A person who has for years suffered a progressive loss of high-frequency hearing is therefore likely to find his first experience with a hearing aid somewhat dismaying. If it will enable him to comprehend speech, he will also rediscover the squeaks and clatter previously screened from him by his own diminished hearing. Almost any one inured to the semi-silence of hearing loss may require some time to become readapted to loud sounds. Sensitive individuals may need several months or more to become accustomed to fuller hearing. Eventually most users of hearing aids come to overlook the inevitable noises for the sake of hearing speech with ease.

Feeling that a hearing aid worn in the open is too conspicuous, some people wear their aids under the clothing. Recently, some manufacturers have provided a transparent plastic tube that acts like a speaking tube, leading from the earphone—which may then be concealed in the hair or beneath a collar—to the transparent plastic earmold. Both of these means for hiding the hearing aid decrease the efficiency of the hearing aid for high-frequency sounds. The consonant sounds, which are very important in the understanding of speech, are in the highest pitch range. If the decreased efficiency at high frequencies gives the user trouble, he should discard the devices used for concealment: inadequate hearing may be more permanently conspicuous than an effective hearing aid worn in full view.

There are several tests that an individual can use to assist him in deciding whether he is getting the most help from his hearing aid. An inexact but very practical method for finding out how it behaves is to make an articulation test.

An articulation test is based upon the idea that the primary purpose of a hearing aid is the communication of speech. It is simply a refined method for talking to a subject and determining how much of the speech he can understand. Because understanding is involved, ordinary words common to everyone's daily life must be used. An attempt is made to choose words that represent a good sample of the sounds that make up speech. A set of such word lists, the PB or "phonetically balanced" word lists, has been developed at the Psycho-Acoustic Laboratory of Harvard University.

Two of these PB word lists are given in table 1. One list suffices for a single test, but smaller parts of a single list will not be adequate, because all the speech sounds will not be tested in their proper ratio. To avoid the effects of memory, the words should be copied on cards so that they can be presented in random order. A person who is trying out a hearing aid should get a friend to make this test with him. He should not face the reader, in order that lip-reading will not affect the result (see fig. 4).

The presentation of the words should be done carefully. To present them naturally, they should be spoken in a sentence in a normal conversational tone. The sentence must be chosen so that the test

FIGURE 4. *An articulation test with a phonetically balanced word list provides a simple means for judging a hearing aid.*

The user turns his back to the reader so that his only clue to the identity of the word is the sound reaching his ear. The words (see table 1) are copied on cards and read in random order to avoid the effects of memory.

TABLE 1. *Word lists for articulation tests*

PB-50 List 1		PB-50 List 2	
1. ache	26. muck	1. bath	26. neat
2. air	27. neck	2. beast	27. new
3. bald	28. nest	3. bee	28. oils
4. barb	29. oak	4. blonde	29. or
5. bead	30. path	5. budge	30. peck
6. cape	31. please	6. bus	31. pert
7. cast	32. pulse	7. bush	32. pinch
8. check	33. rate	8. cloak	33. pod
9. class	34. rouse	9. course	34. race
10. crave	35. shout	10. court	35. rack
11. crime	36. sit	11. dodge	36. rave
12. deck	37. size	12. dupe	37. raw
13. dig	38. sob	13. earn	38. rut
14. dill	39. sped	14. eel	39. sage
15. drop	40. stag	15. fin	40. scab
16. fame	41. take	16. float	41. shed
17. far	42. thrash	17. frown	42. shin
18. fig	43. toil	18. hatch	43. sketch
19. flush	44. trip	19. heed	44. slap
20. gnaw	45. turf	20. hiss	45. sour
21. hurl	46. vow	21. hot	46. starve
22. jam	47. wedge	22. how	47. strap
23. law	48. wharf	23. kite	48. test
24. leave	49. who	24. merge	49. tick
25. lush	50. why	25. move	50. touch

words cannot be inferred from the rest of the sentence. A carrier sentence commonly used is "You will say . . . now". This sentence has the advantage that the "a" sound in "say" is a high-level sound and can be used by the speaker for checking on his voice level. The sentence should be spoken at ordinary conversational level.

It is unlikely that the person making the test will get 100 percent of the words correctly. Even under ideal communication conditions (with two persons in the same quiet room, but not facing each other) the random word articulation scores are usually 95 percent. Apparently, individuals with normal hearing actually judge the remaining 5 percent of the words in ordinary conversation by familiarity, context, or lip-reading.

By noticing the particular speech sounds that are missed by the listener in writing down the word list, and comparing them with the chart in figure 2, it is possible to get some idea of the particular way in which the hearing aid fails to compensate for hearing loss.

Perhaps the simplest way for determining whether a hearing aid has a resonance is to listen to footsteps or a typewriter and note whether a particular note seems to be favored. If there is access to a piano, the resonance can be readily noticed by having some one play through the keyboard range with a uniform touch. If the hearing aid's gain is uneven, certain notes will sound markedly louder or softer than the rest.

5. Guidance in Choosing a Hearing Aid

The choice of a particular hearing aid is made under difficult conditions. Numerous makes are on the market, offering a wide variety of choices. The person making the selection is usually not able to compare the result of wearing a hearing aid with the experience of normal hearing. Fortunately, unbiased guidance on choosing hearing aids is available.

An information service on the problems of the hard-of-hearing is maintained by the Volta Bureau, 1537 35th Street NW, Washington 16, D. C. This organization was founded by Alexander Graham Bell to serve as an information center for the hard-of-hearing and for teachers of the deaf. It has prepared literature on the problems of hearing loss, available to the public upon written request. Similar assistance is offered by the American Hearing Society, 817 14th Street NW, Washington 5, D. C. The Society is the national organization of the numerous local societies formed for mutual assistance by persons suffering from hearing loss. The American Hearing Society will send to any inquirer a list of hearing aid services available in its own chapters, in colleges and universities, and in hospitals.

The American Medical Association maintains a list of hearing aids that meet its standards as to performance and as to the ethics of the manufacturer's sales policy. The performance specifications are not strict, but the purchaser of an "accepted" instrument may be reasonably certain that the hearing aid provides amplification that is at least sufficient for a person with moderate hearing loss. The list of accepted hearing aids may be obtained from the Council on Physical Medicine and Rehabilitation, American Medical Association, 535 North Dearborn Street, Chicago 10, Ill. The same list is also available from the American Hearing Society.

At the time of acceptance of a particular make and model of hearing aid by the Council, a brief report on the measured performance of the instrument is published in the current issue of the Journal of the American Medical Association. This is probably the most widely circulated report of the properties of particular makes of hearing aids. The Journal can usually be consulted in the public libraries of the larger cities and towns.

In recent years, local hearing societies (chapters of the American Hearing Society) have set up hearing-aid guidance clinics to assist hard-of-hearing persons in their community in choosing hearing aids. The clinic offers people the opportunity to try out and compare various makes of hearing aids without any sales pressure. Manufacturers are invited to submit instruments representing their current models. Usually some advice is available on what to listen for in trying out the instruments, but the choice is left to the user. Having established a preference, the person goes out to a dealer and buys the make of his choice.

Manufacturers are willing to submit instruments under this arrangement because it reduces their selling costs and minimizes customer dissatisfaction. Only instruments meeting the acceptance standards of the American Medical Association are used in these clinics, as an assurance that the sales policies of the manufacturers are above reproach. Although not all manufacturers are represented—some of them prefer to control their sales more directly—a wide variety of makes is represented. It has been pointed out that the hearing aid clinic offers a positive protection against buying an unsuitable instrument, even though it cannot be sure of guiding a person to the instrument best suited for him. As with most nonprofit civic enterprises, hearing aid clinics are supported by local universities or local community funds, although many of them charge a nominal fee for their services to those who can pay it. A list of these clinics is given in appendix 2.

A person shopping for a hearing aid may find it helpful to take with him a person with normal hearing. Speech articulation tests used in trying out the hearing aid may be "weighted"; often this may be unconscious on the part of the sales person, who may habitually speak in a louder tone of voice when confronted by a listener wearing a hearing aid. Hearing aids should be tried out by the user in his ordinary surroundings. Some companies provide a trial plan, occasionally charging a nominal rental that may be applied to the price of the instrument if it is purchased.

6. Care of a Hearing Aid

A hearing aid is somewhat different from other devices that a person uses in his daily life, and a small amount of special care in handling it may pay substantial dividends in increased usefulness and better performance. The sensitive crystal element in most microphones and in some earphones is injured by exposure to high temperatures, and will be ruined permanently by temperatures above 120° F. Such temperatures may be produced locally if the aid is left lying in the sun, in a closed parked car, or too near a radiator. The aluminum foil on the microphone is a basic part: the foil should not be pressed or scratched, or the quality of the transmitted sound may suffer.

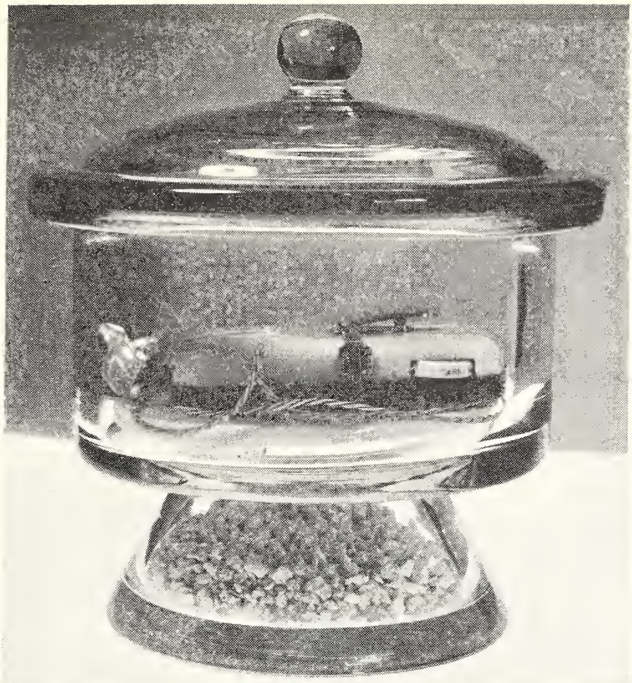

FIGURE 5. *A hearing aid that has "passed out" because of humidity is easily dried out by putting it in a desiccator—a tight container with a chemical drying compound.*

The aid rests on a perforated plate above the drying agent (base of desiccator). The desiccator shown is the type used by chemists, but any tight box will do. The hearing aid must be kept from direct contact with the drying agent.

The electrolyte in the batteries is either a moderately strong acid or a strong alkali and may cause damage if the battery cases leak. This is likely to happen when the batteries are run down. For this reason, it is advisable to separate the batteries from the instrument when it is not being worn, especially if the batteries are mounted in the amplifier case. Since the battery case is consumed in the chemical process that produces electricity in the battery, it is usually not practical to recharge the batteries. Although this is sometimes suggested as an economy measure, the probability of leakage or bursting is greatly increased because the case material is not renewed by recharging. There are some cells on the market designed for recharging. They are true storage batteries and are usually somewhat larger, heavier, and more expensive than dry-cell batteries. In an emergency, flashlight cells can be substituted for hearing aid cells of the same size. However, flashlight cells are designed for heavy but intermittent drains, and may not give as long service as the hearing aid cells, which are built for the continuous light drain taken by hearing aids.

In warm, humid climates a hearing aid may "pass out" temporarily on a particularly damp day. The microphone and earphone are hermetically sealed, but the seal may not remain perfect, and occasionally the loss in sensitivity is due merely to moisture condensing on the exterior surfaces of the amplifier parts, between the wiring. A hearing aid may be dried out by keeping it in a desiccator[1] when not in use (fig. 5). It can also be dried out by placing it overnight in a mechanical refrigerator, provided it is not exposed to moist air before it returns to room temperature. Neither a "cold-wall" refrigerator nor an ice-box will work, however, because the drying action depends on condensing the moisture on the refrigerator coils.

[1] A desiccator is a container having a chamber in which a chemical compound for absorbing water may be placed. The compound will remove moisture from objects stored in the container, and may be renewed when saturated. Desiccators are sold by chemical and laboratory supply firms.

Appendix 1. Scale of Degrees of Hearing Loss[a]

(Prepared by the Committee on Hearing of the National Research Council)

Class	Name	Loss for speech, in decibels[b]	Remarks
A	Normal	Not more than 15 in worse ear.	Both ears within normal limits. No difficulty with faint speech.
B	Near normal	More than 15 but not more than 30 in *either* ear.	Has difficulty only with faint speech.
C	Mild impairment.	More than 30 but not more than 45 in *better* ear.	Has difficulty with normal speech but not with loud speech.
D	Serious impairment.	More than 45 but not more than 60 in *better* ear.	Has difficulty even with loud speech.
E	Severe impairment.	More than 60 but not more than 90 in *better* ear.	Can hear only amplified speech.
F	Profound impairment.	More than 90 in *better* ear	Cannot understand even amplified speech.
G	Total loss of hearing in *both* ears.		Cannot hear any sound.

[a] This scale refers solely to hearing and does not take into consideration a man's competence with hearing aids, lip reading (speech reading), etc.
[b] The classes are defined by "decibels loss of hearing for speech". Until suitable technical facilities for direct measurement by speech audiometry are available, the loss of hearing for speech shall be calculated from pure-tone air-conduction measurements by averaging the hearing losses at 500, 1,000, and 2,000 cycles per second, or at 512, 1,024, and 2,048 cycles per second if the available audiometers are so calibrated. A person should be classified one class lower than indicated by the average value if, with an average loss of 10 decibels or more, his hearing loss for any one of the three frequencies is greater by 25 decibels (or more) than the least of his three losses.

Appendix 2. Hearing-Aid Clinics[1]

Appointments must be made in advance. In most cases a fee is charged. Inquire about this so that there will be no misunderstanding.

ALABAMA

Talladega ..... Dowling Hospital, Alabama Hearing Center.
Tuscaloosa ..... University of Alabama, Speech and Hearing Clinic.

[1] Furnished by *THE VOLTA BUREAU*, an information center on hearing impairment, 1537 35th St., N. W., Washington 16, D. C.

CALIFORNIA

Bakersfield	Kern County Hospital, 1830 Flower St.
Inglewood	Hearing Clinic, Masonic Temple, South Grevillea Ave.
Los Angeles	Los Angeles Eye and Ear Hospital, 500 South Lucas Ave.
	Los Angeles State College, 855 North Vermont Ave.
San Francisco	Mount Zion Hospital, 1609 Scott Street.
	San Francisco State College, Herman and Buchanan Sts.
	Veterans Hospital, Fort Miley, 42d and Clements Sts. (for veterans).
Palo Alto	Stanford University, Department of Speech.
Whittier	Whittier College, Speech and Hearing Clinic.

COLORADO

Denver	University of Denver, Speech and Hearing Clinic.

CONNECTICUT

Hartford	Hartford Hearing League, 252 Asylum St.
New Haven	Grace-New Haven Community Hospital (Yale University Medical School), 789 Howard Ave.

DELAWARE

Wilmington	The Delaware Hospital, Audiology Clinic, 501 W. 14th St.

DISTRICT OF COLUMBIA

Washington	Hearing Rehabilitation Center, 1911 R St., N. W.
	Walter Reed General Hospital, Audiology and Speech Correction Center, Forest Glen Section (for servicemen).
	Washington Hearing Society, 2431 14th St., N. W.

FLORIDA

Gainesville	University of Florida, Speech and Hearing Clinic.

GEORGIA

Atlanta	Veterans Administration Regional Office, Belle Isle Bldg., 105 Pryor St., S. E. (for veterans).

ILLINOIS

Chicago	Chicago Hearing Society, 30 West Washington St.
	St. Luke's Hospital, Audiology and Speech Correction Service, 1439 S. Michigan Ave.
	University of Illinois, College of Medicine, Speech and Hearing Clinic.
Evanston	Northwestern University, School of Speech and University College.
Normal	Illinois State Normal University, Department of Speech.
Peoria	Bradley University, Speech and Hearing Clinic.
Rockford	Rockford College, Speech Department.
Urbana	University of Illinois, Speech and Hearing Clinic.

INDIANA

Bloomington	Indiana University, Speech and Hearing Clinic.
Lafayette	Purdue University, Speech and Hearing Clinic.
Muncie	Ball State Teachers College, Speech and Hearing Clinic.
Terre Haute	Indiana State Teachers College, Hearing Clinic.

IOWA

Iowa City	University of Iowa, Department of Speech.

KANSAS

Kansas City	University of Kansas Medical Center, 39th and Rainbow.
Wichita	University of Wichita, Speech and Hearing Clinic.

LOUISIANA

Baton Rouge	Louisiana State University, Speech and Hearing Clinic.
New Orleans	New Orleans League for Better Hearing, 530 Capdeville at Camp St.

MAINE

Portland	Portland Hearing Society, Hearing Center, 653A Congress St.

MARYLAND

Baltimore	Baltimore Hearing Society, 322 North Charles St.
	Johns Hopkins Hospital, Hearing and Speech Center.

MASSACHUSETTS

Boston	Boston Guild for the Hard of Hearing, 283 Commonwealth Ave.
	Emerson College, Institute of Speech.
	Massachusetts Eye and Ear Infirmary, The Winthrop Foundation and Clinic for the Deaf. (For children) 243 Charles St.
Springfield	Springfield Hearing League, 1694 Main St., Rooms 209–11.
Worcester	Worcester Hearing League, 214 Day Bldg., 306 Main St.

MICHIGAN

Ann Arbor	University of Michigan, Speech Clinic, 1007 East Huron St.
Detroit	Detroit Hearing Center, 535 West Jefferson.
	Wayne University (veterans only).
East Lansing	Michigan State College, Department of Speech.
Kalamazoo	Constance Brown Society for Better Hearing, 210 Pratt Bldg.
Mount Pleasant	Central Michigan College of Education, Speech and Hearing Clinic.

MINNESOTA

Minneapolis	University of Minnesota, Speech Clinic.
Rochester	Mayo Clinic, Audiological Section.

MISSOURI

Columbia	University of Missouri.
Kansas City	Veterans Administration Regional Office, 1828 Walnut St. (for veterans).
St. Louis	Central Institute for the Deaf, 818 South Kingshighway.

NEBRASKA

Lincoln	University of Nebraska, Speech and Hearing Laboratories.

NEW HAMPSHIRE

Manchester	New Hampshire Hearing Society, 795 Elm St.

NEW JERSEY

Newark	State Teachers College, 187 Broadway (diagnosis and consultation only).
Paterson	Paterson League for Hard of Hearing, 182 Ellison St.
West Trenton	New Jersey School for the Deaf.

NEW YORK

Brooklyn	Apostolate for the Deaf and the Hard of Hearing, 191 Joralemon St.
New York	Columbia-Presbyterian Medical Center, Vanderbilt Clinic, 622 West 168th St.
	Hearing Rehabilitation Center, 330 East 63d St.
	Manhattan Eye, Ear and Throat Hospital, Hearing Conservation Clinic, 210 East 64th St.
	N. Y. City Department of Hospitals, Otology Division, 80th and East End Ave.
	N. Y. Eye and Ear Infirmary, 2nd Ave. and 13th St.
	N. Y. Hospital-Cornell Medical Center, 525 East 68th St.
	N. Y. League for the Hard of Hearing, 480 Lexington Ave.
	Nitchie School of Lip Reading, 342 Madison Ave.
	Veterans Administration Regional Office, Audiology Unit, 252 7th Ave. (for veterans).
Rochester	Rochester Hearing Society, 130 Clinton Ave., South.
Syracuse	Syracuse University, Conservation of Hearing Center, 610 E. Fayette.
Utica	Speech and Hearing Center, The Children's Hospital Home.

NORTH CAROLINA

Durham	Duke University, Division of Otolaryngology (testing and consultation).
Winston-Salem	Bowman Gray Clinic.

OHIO

Cincinnati	Cincinnati Speech and Hearing Center, 616 Walnut St.
Cleveland	Cleveland Hearing and Speech Center, 11206 Euclid Ave.
Columbus	Ohio State University, Speech and Hearing Clinic.
Kent	Kent State University, Speech and Hearing Clinic.
Toledo	Toledo Hearing League, 2313 Ashland Ave.
Youngstown	Youngstown Hearing Society, 69 Illinois Ave.

OKLAHOMA

Norman	University of Oklahoma, Hearing Clinic.
Oklahoma City	University of Oklahoma, Speech and Hearing Clinic in Crippled Children's Hospital.

PENNSYLVANIA

Lancaster	Hearing Conservation Center of Lancaster County, 24 N. Lime St.
Philadelphia	Eversden, Marguerite V., 1918 Spruce St.
	Temple University, School of Medicine, Hearing Aid Clinic.
	University of Pennsylvania Hospital, Audiology Section.
	U. S. Naval Hospital, Aural Rehabilitation Center.
Pittsburgh	Pittsburgh Hearing Society, Granite Bldg., 6th Ave. and Wood St.
	University of Pittsburgh, Eye and Ear Hospital, 230 Lothrop St.
Reading	The Reading Hospital.
State College	Pennsylvania State College, Speech and Hearing Clinic.

RHODE ISLAND

Providence	Providence League for the Hard of Hearing, 42 Weybosset St.

TENNESSEE

Memphis	Memphis Speech and Hearing Center, University of Tennessee, 874 Monroe.

TEXAS

Austin	University of Texas, Speech and Hearing Clinic.
Denton	Texas State College for Women, Hearing and Speech Clinic.

UTAH

Salt Lake City	University of Utah, Speech and Hearing Clinic.

VIRGINIA

Charlottesville	University of Virginia, Hearing and Speech Clinic.
Richmond	Medical College of Virginia, Ear, Nose and Throat Clinic.

WASHINGTON

Seattle	University of Washington, Department of Speech.

WISCONSIN

Madison	University of Wisconsin, Department of Speech.
Milwaukee	Marquette University, Speech Clinic and Hearing Laboratory, 625 N. 15th St.
	State Teachers College, Hearing Aid Clinic.

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