HEARING AND HEARING AIDS—A LAYMAN'S NOTIONS

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Consideration of hearing logically starts with the structure and function of the several parts of the human ear. The auditory portion of the brain, crucial though it is, must be taken for granted here. A chart of thresholds for different tones, the audiogram, not merely indicates normal or defective hearing of pure tones but provides important clues as to the nature and cause of a specific hearing loss. Tests sampling reactions to the more complex sound patterns used in speech are presumably more realistic yet more difficult to construct and interpret. Merely hearing the bursts of sound energy is not enough; the user must be able to understand and react meaningfully. An inappropriate response caused by an innocent misunderstanding can lead to ridicule or chaos.

The hearing aid must amplify the sounds so they seem comfortably loud to the user but must not deliver an excessive maximum power output lest initially loud environmental noises become painfully loud to the user. Fidelity of amplification, though now substantially sacrificed to allow a dramatic degree of miniaturization, has an important effect on clarity of understanding of complex speech signals. One may suggest, too, that listening through a distorted system with poor transient response in serious background noise may cost the user both mental and physical fatigue. Initial physical tests of hearing aids as a screening measure, prescription of the most appropriate aid for an individual, and careful auditory training of the user (including instruction in reading of lips and other facial gestures) are important steps in auditory rehabilitation.

Structure and Function of the Ear

As has been said, the ear, like all Gaul, is divided into three parts. These are grouped as the outer, middle, and inner ear (Fig. 1).

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Based on various discussions and reading, though the misunderstandings are the sole responsibility of the author.
FIGURE 1.—Sectional diagram of the human ear. (Illustration courtesy of Sonotone Corporation, Elmsford, New York.)
Murphy: A Layman’s Notions on Hearing

The first of these, the outer ear, consists of an appendage (the pinna, which not only provides some slight funnel-like amplification but decorates the side of the head, provides a challenge for maxillofacial prosthetics, and supports eyeglasses) and an opening into the temporal bone of the skull. This ear canal, exposed to pulsating sound pressure of the outside air, ends with the eardrum or the tympanic membrane, shaped rather like a tilted Chinese coolie’s hat.

The second portion of the ear, the middle ear, is a small, air-filled space which likewise communicates with the outside air through the Eustachian tube which runs from the middle ear to the back of the throat—a notorious route for infection. The middle ear contains three bones, the auditory ossicles; named from their shapes, these are the hammer, anvil, and stirrup or malleus, incus, and stapes. Incidentally, these are the smallest bones in the human body, complicating otological surgery. The middle ear also contains two tiny muscles which, functioning under very rapid reflex control, retard the movement of the auditory ossicles when loud sound occurs.

Buried deep in the temporal bone is the third portion, the inner ear. Well protected by the hardest bone in the human body, the inner ear contains the cochlea, a snail-shaped organ which contains the peripheral nerve elements of the sense of hearing. Within the cochlea is the organ of Corti which contains approximately 30,000 hair cells. Nerves leading from these hair cells join to form the auditory tract which leads from the inner ear to the temporal lobe of the brain.

The Normal Ear

The normal function of the ear begins when air-borne vibration reaches the external ear. As Dr. Olsen discusses in a later paper in this issue, the head may cast a “sound shadow” on one external ear when sound approaches from the opposite side of the body. The pinna, too, may cast a slight “sound shadow” on a hearing-aid microphone. Alternatively, the pinna, perhaps aided occasionally by a hand cupped behind the ear, helps to direct sound into the ear canal and to reduce extraneous noise behind the listener. These shadow effects are minor at low frequencies but significant at high frequencies. During approach of a parade, for example, the low rumble of drums is apparent around a corner, but the high, shrill sound of fifes is most evident only after the band is in sight.

Sound waves traveling through the external ear canal set the eardrum membrane into corresponding vibration. The handle of the hammer or malleus, which is attached to the tympanic membrane, is likewise set into vibration and, in turn, vibrates the incus and the stapes. The footplate of the stapes is set into a small opening to the inner ear.
called the oval window and normally sealed by a rather flexible soft tissue. The vibration of the footplate of the stapes, efficiently driven from the eardrum through the bony levers, sets in motion the fluids of the inner ear. This pulsating hydraulic pressure courses through the coils of the cochlea to be dissipated back into the average atmospheric pressure of the middle ear through a reciprocal action of the round window (Fig. 2). This fluid vibration, while traveling through the cochlea, sets into vibration the basilar membrane, upon which rests the organ of Corti. The tectorial membrane, into which fine upper ends (hairs) of the hair cells are embedded, overlies the organ of Corti. The bending of the basilar membrane results in a shearing action on the hair cells, which by some unknown means leads to stimulation of small nerve fibers of the eight cranial nerve. This stimulation, traveling by a tortuous route, must arrive at the temporal lobe of the brain before it is interpreted as sound.

![Diagram of auditory apparatus](image)

**FIGURE 2.—Auditory apparatus (schematic).**

**The Pure-Tone Audiogram**

Hearing is traditionally tested in terms of pure-tone audiograms (Fig. 3). A single-frequency signal, at each of many frequencies from 125 through 8000 Hertz (or cycles per second), of varying intensity is turned on and off, and the patient signals whenever he hears the single pitch, even very faintly. In this way, the threshold, or intensity at which he barely detects that tone, is determined. Then other frequencies are tested similarly. The intensities are compared with normal values for large groups.

Typically the test is conducted separately for each ear by two methods. The first uses air conduction from a snugly fitting earphone or receiver leading sound into the ear canal. In the second test, with bone conduction, a vibrator over the mastoid bone back of the ear bypasses the ear canal, membrane, and ossicles to stimulate the inner ear directly.

Sound level intensity is typically measured in decibels, abbreviated dB. (Spelling with a capital B is now preferred because the basic unit
is named in honor of Alexander Graham Bell, originally a teacher of the deaf as well as later developer of the telephone. Decibels are measured on a logarithmic scale relating power to an arbitrary reference intensity. Multiplying the power by 100 is equivalent to an increase of 20 decibels (10 times logarithm of 100 to base 10) in intensity. The logarithmic scale not only conveniently covers an extremely wide range but approximates the psychological impressions of changes of physical intensity.

The normal ear is most sensitive at about 3500 cycles per second, or 3500 Hertz, but it is appreciably less sensitive both at low frequencies or at much higher frequencies (Fig. 4). (A “normal” individual may well deviate, at least at some frequencies, by 10 to 20 dB from the average of a large group of persons with no known pathology.) Therefore, more physical intensity of vibration is needed at lower or higher frequencies to reach the threshold of sensation in the normal individual. As higher intensities are used, this curve becomes flattened,
until in quite high sound power levels (such as a subway train), the normal ear has about the same relative sensitivity across a wide-frequency spectrum. Thus, there is a rather flat or horizontal contour of equal loudness at high intensity in contrast to the U-shaped contours near threshold.

The conventional audiogram is plotted in decibels or physical intensity downward from a zero calibration corresponding to average or normal threshold of hearing of a very large population sample with no known hearing defects. Thus the U-shaped threshold curve of Figure 4 is stretched out into a horizontal line labeled "0" at the top of audiograms (Fig. 3). The conventional audiogram is plotted on a horizontal logarithmic frequency scale from 125 Hertz out to 800 Hertz, more than adequate to assess ability to understand speech, though the normal ear of a young person will also detect sounds from 20 to 15,000 or sometimes 20,000 Hertz.

Incidentally, echo location of obstacles by blind individuals is most effective at high frequencies, probably 9,000 to 10,000 Hertz and higher. Thus, the conventional audiogram alone will not necessarily reveal mobility difficulties for a blind person or how much of this
echo-detection ability might be expected. Special efforts should be made to evaluate hearing ability at high frequencies for blind or partially sighted patients. It is also obvious that such patients cannot expect to benefit from lipreading, so hearing losses even in speech frequencies are unusually serious.

Hearing Losses

The resulting audiogram is important for diagnosing various types of hearing losses, as well as serving as a guide for the selection of hearing aids. Hearing loss is generally classified into two categories—conductive and sensorineural. There may, of course, be mixtures of both types in the same individual. Cases with conductive hearing losses show better sensitivity to bone-conducted stimuli, whereas cases with sensorineural losses show equal sensitivity to bone-conducted and air-conducted stimuli.

Although the ear is extraordinarily well designed and remarkably well protected, nevertheless it is subject to various types of breakdown. The first general classification of hearing pathology, called a conductive hearing loss, involves those structures that conduct the sound from the outside air to the nerve. These disorders may be caused by a blockage of the external ear canal, a defect or perforation of the eardrum, an accumulation of fluid in the middle ear, an infection of the middle ear, fixation of the ossicular chain through disease processes, or many other factors. All of these result in a hearing impairment of mild to moderate degree although the nerve of hearing remains intact. Fortunately, conductive hearing losses now are, for the most part, reversible. That is, medical or surgical treatment will result in restoration of hearing.\(^b\)

If the patient's difficulty is predominantly in loss of or damage to the eardrum membrane or to the chain of small bones (ossicles) leading to the bony "piston," thus hampering transfer of vibration of the membrane across the middle ear to the fluid of the inner ear, hearing by bone conduction will be very much better than that through air. The bone-conduction receiver per se is capable of covering the necessary frequency range but in attempting to vibrate the hearing organ within the relatively massive bony skull, the receiver must drive through a relatively soft layer of skin and fat. Bone-conduction vibrators thus encounter more difficulty in attempting to transmit high frequencies.

\(^b\) In the old adage and a current song, "Beans in Your Ears!"

\(^c\) For popular descriptions as well as good illustrations of the ear, see "Sound and Hearing," by S. S. Stevens, Fred Warshofsky, and the Editors of Life, Time, Inc., 1965.
The bone-conduction vibrator driving a stiff and heavy skull also requires far more power than an air-conduction receiver driving mainly a fragile column of air and tiny moving parts.

Some years ago the Prosthetic and Sensory Aids Service sponsored research of the late Dr. H. G. Kobrak of Wayne University, Detroit, on a simple prosthesis for certain cases of conductive deafness in which eardrum membrane and ossicles of the middle ear were absent (after blast injury or prolonged middle-ear infection). In such cases sound waves entering the ear canal struck equally upon the oval and round windows. (In the normal or intact person, as we saw above, sound pressure on the eardrum membrane is efficiently transmitted by the hammer and anvil to the stirrup or stapes, the last bone of the chain, which drives its footplate inward to displace fluid in one channel of the inner ear, thus stimulate the hair cells, and reciprocally displace the round window outward against air in the middle ear to accommodate the moving fluid of the inner ear. Thus vibration from sound waves striking the eardrum membrane normally is transmitted preferentially to the oval window.) When the sound pressure abnormally struck equally upon the two windows, an abnormal canceling effect occurred and such a patient “with a hole in his head” and lacking membrane and ossicles suffered an appreciable hearing loss.

Dr. Kobrak reasoned that he could restore the preferential transmission to the oval window. The mere addition of a protecting plug of a special ointment in the round window niche, shielding the round window from incident sound waves entering the middle ear to strike the oval window but leaving a bubble of air which could compress slightly to absorb the compensatory outward movements of the round window, proved to increase remarkably the hearing ability of such an individual. Furthermore, this gain in hearing occurred without the cost, distortions, or other problems of an electronic hearing aid. (As Dr. Kobrak often mentioned, each such addition of ointment was an experiment in the physics and physiology of hearing.) The ointment in fact restored very simply everything but the minor leverage effect of the ossicles, so hearing was almost normal. This and other experiments are described in Dr. Kobrak’s book, *The Middle Ear*, which was posthumously published.

Drs. Shambaugh and Carhart of Northwestern University, under another VA contract, then applied this simple concept to improvement in the hearing of individuals who had received the fenestration operation for otosclerosis or bony adhesion of the footplate of the stapes to adjacent bone. In the fenestration operation a new window (in Latin, fenestra) was made into the inner ear to replace the abnormally restricted oval window. By their modified use of ointment, Drs. Shambaugh and Carhart found only a small average improvement in the
hearing of a large series of patients, but they were struck by the observation that those individuals who had failed to obtain as much improvement as would be expected from the fenestration surgery were most benefited, raising these less fortunate patients substantially to the level which should have been expected from the operation. In recent years several more effective surgical techniques have been developed, such as that for “mobilizing” the footplate, thus reducing the indications for performing the fenestration operation and therefore the need for this improvement.

Other recent pharmacologic treatments and surgical procedures also have helped to eliminate conductive hearing losses as common and serious problems. Drugs have reduced risks of serious and prolonged middle-ear infections which formerly caused major hearing losses. Various grafting methods and prostheses are now available to replace eardrum membrane, ossicles, or both portions. Thus, fortunately, what was formerly a major cause of hearing loss is now curable.

The second classification of hearing pathology comprises those affecting the inner ear and hearing nerve. These cause a sensorineural hearing impairment, usually greater at higher frequencies. Exposure (especially if prolonged and repeated) to intense noise, presbycusis or the aging process of the ear, Meniere’s disease, toxic drugs, or viral diseases may all cause damage to or destruction of the hair cells of the organ of Corti or of the nerve fibers themselves. In most cases this damage is permanent and irrevocable, at least as far as the present state of knowledge is concerned. Then neither medical nor surgical treatment will yet result in restoration of hearing. Sensorineural hearing losses may be mild, moderate, severe, or essentially total. Most congenital deafness, whether hereditary or environmental, also falls into the category of sensorineural hearing impairment. A mixture of conductive and sensorineural loss may occur in a given case.

With advancing age the upper frequency limit of normal hearing generally decreases; in other words, the audiogram slopes downward at the right. Mild losses of high frequencies may only affect enjoyment of high-fidelity music (perhaps related to a tendency of some users of hi-fi equipment to exaggerate the treble emphasis) and precision of echo location of small obstacles; since speech frequencies are very much lower, the individuals concerned may be unaware of any hearing loss (Fig. 3). More severe losses, however, may interfere with high-frequency speech sounds, leading to confusion between singular and plural and to a variety of other possible misunderstandings of f, v, etc.

Merely repeating the same word in a louder voice to a person who has failed to understand thus may not help the individual very much if his hearing loss is appreciable in a frequency range needed to understand the word. Sometimes the meaning can be communicated more
effectively by choosing a synonym, which may happen to have a
different combination of frequencies—and probably a different series
of facial gestures which in face-to-face conversation may chance to
improve the possibilities for lipreading.

Measures of Speech

There are relatively arbitrary methods of calculating effective aver-
age hearing loss from a pure-tone audiogram, as for calculating disa-
bility or compensation ratings. In addition, speech reception threshold
(abbreviated SRT) is often measured. A sample series of words with
two syllables (each with equal stress upon the two syllables, called
spondees or spondaic words) may be given at varying intensity.
Speech reception threshold (SRT) is said to be the level in relation to
normal hearing at which the patient recognizes half the words correctly.

In addition to the audiogram and the speech reception threshold,
another measure of ability to understand or discriminate speech is
frequently used. Lists of phonetically balanced (PB) words were pre-
pared, originally under the auspices of the Office of Scientific Research
and Development during World War II for testing aircraft and other
military communication systems, these were later refined in various
ways (partially with the sponsorship of the Veterans Administration)
for use specifically on hearing aids. Some lists are read by the testing
official in live voice, others are recorded on phonograph records or
magnetic tapes. The basic idea is to have numerous comparable lists
of relatively common words which sample accurately the statistical
distribution between various acoustic frequencies in the language.

Hopefully, simple and easy words can be chosen which do not
require advanced education or special cultural background, but this
goal is not fully reached. Obviously the language and accent of the
patient must be considered in analyzing the results. One cannot expect
comparable results by simply translating literally the actual words
which have been calibrated for English into a foreign language with
radically different acoustics and perhaps appreciably different sta-
tistical probabilities of use of different words and their synonyms.
Neither can one expect to use words developed with a general Ameri-
can dialect for testing a recent immigrant or for studies in an area
of the United States where a different dialect is common. One should
not score as incorrect the pronounced response “heat” of an individual
responding orally to a test word “hit” if that individual’s accent in-
clines him to pronounce the short i (which he actually heard) as long
e. While numerous attempts are being made at many laboratories,
including work at Houston Speech and Hearing Center, to develop
other measuring scales, the percent discrimination score as shown by correct response to various versions of these phonetically balanced or PB words is still very widely used.

As shown in Figure 5, schematically, the percentage of words understood correctly rises in an S-shaped fashion as the test becomes "easier." There are many ways in which the task of the subject may become easier—louder signal (greater physical intensity or more dB) in quiet conditions, greater ratio of the intensity of the signal S to that of some background noise N (higher signal/noise ratio, S/N, also in dB), or greater ratio of signal S to competition C, conversation or a different voice reading a long text (S/C).

![Figure 5](image)

**Figure 5.**—Discrimination scores for isolated words.

When a task is sufficiently difficult, as at A, at the left, none of several possible systems allows appreciable accuracy of understanding regardless of the level of effort and attention. Conversely, when the task is sufficiently easy, as at C, each of several systems allows very high (perhaps substantially perfect) performance. An important test of inherent difference between systems, though, is under moderately
difficult conditions like B. In these circumstances, one amplifying system allows dramatically higher percentages of correct response than another.

Fortunately, as shown in Figure 6, connected speech can be understood, with the aid of context, with circumstances providing considerably less than 100 percent correct understanding of the isolated words; that is, the experimental curve bulges far above a 45-deg. diagonal or direct proportionality; these tests are deliberately conducted with loudspeakers or earphones, using hearing alone. In many everyday situations, of course, lipreading permits additional improvement. Thus a situation like (3) in Figure 5, never allowing more than perhaps 80 percent correct understanding of test words under even the “easiest” circumstances, may yet permit reasonably intelligent conversation. Nevertheless, the relative merits of the listening systems are clear: system (1) allows either slight understanding under very difficult circumstances like A, or else adequate (say over 80 percent) comprehension under reasonably difficult circumstances like B where system (2) offers little and system (3) practically nothing. Often, of course, systems are less dramatically separated.

One may imagine various combinations of hearing abilities, communication systems or hearing aids, and listening circumstances which can be compared by these types of curves. Situation (1) in Figure 5, for example, might be a normal individual listening to a single speaker, in a noisy factory or party at (A) or in a quiet office at (C). Situation (2) might then represent the performance of a person with a conductive hearing loss. Then curve (3) might represent a patient with sensorineural loss, probably inherently limited in ultimate performance even under favorable circumstances and disproportionately handicapped by background noise or competing conversations which normal individuals can override. Similarly, the three curves might represent, perhaps in exaggerated fashion, performances of a single listener using three types of amplifying systems, (1) a hi-fi set, (2) a good quality table radio, and (3) a very inexpensive portable radio.

Occasionally, though, a task actually is easier with what seems at first glance a more difficult condition, so the curves seem reversed. Such a paradox occurs in the tests reported herein by Jerger. The goal is to distinguish between two aids of varying quality. When the listening situation is sufficiently difficult, something like (B) in Figure 5, the difference in quality stands out clearly because understanding is so much better, and easier, with the aid of higher quality. When the task is very easy, though, as at (C), both aids allow high scores without great attention to the signal; then more careful, discriminating attention is needed to distinguish between the two aids. This paradox is resolved as one realizes that anyone can distinguish a skilled musical
artist of high quality from a beginner with crude performance, but only a connoisseur may judge between two internationally famous artists, each performing at a nearly perfect level. Similarly, unhappily, anyone can distinguish a hi-fi set from a present-day hearing aid, especially under noisy circumstances, but selection among hi-fi sets or, at another level, among the best available hearing aids, requires careful discrimination. Physical tests of important acoustical properties should help to form and validate these judgments. Reliance on advertising claims, past performance of a particular make, miniaturization, or appearance of gold plating on a panel or a clip may be misleading.

The Veterans Administration has conducted an intensive program to preserve and, indeed, improve the quality of hearing aids with primary emphasis upon physically measurable aspects of auditory per-
formance, plus consideration of justifiable prices. In 1957 with the aid of a number of consultants a plan was drafted and submitted to the known hearing-aid manufacturers for comment. A number of helpful suggestions were incorporated in the plan as finally put into effect, and small changes have been made from time to time since that date with the aid of a group of independent consultants in audiology and engineering.

Under this plan, each year hearing-aid manufacturers are invited to submit aids for independent tests at the National Bureau of Standards. The raw data are turned over to the Veterans Administration for analysis (done in recent years with the aid of a computer program) into weighted performance scores.

Within the categories of aids designed for mild, medium, or severe loss, the appropriate aids are placed in rank order, in terms of their performance scores. With the aid of the consultants, the top aids in quality point scores are then selected.

The primary concern is for quality, with only the top half in quality point scores considered. There is only secondary concern for price to the Veterans Administration. The points of quality score per dollar, however, are also calculated and considered in the selection of a clinically useful number of aids from among the top half. Thus the manufacturer is doubly encouraged to improve quality, (a) not only to avoid automatic rejection in the lower half, but (b) to strive to improve his aids with the assurance that the Veterans Administration will be willing to pay a proportionally greater price if the manufacturer can demonstrably improve quality. Because of the particular procedures used for these tests, the prices for bulk purchases of substantial quantities, and the unique requirements of the Veterans Administration and its beneficiaries, the results are not considered necessarily useful for other individuals or agencies, so they are not publicized. The raw data on particular samples taken at the National Bureau of Standards, however, are made available to the individual manufacturer concerned to assist him in improving his own quality-control program.

Implicit in this program is some decision as to the various physical factors which might be measured on aspects of performance of a specific hearing aid and the weight to be given to each of the selected factors in relation to clinical usefulness of the aid in assisting an individual’s aural rehabilitation. All factors to be measured were, as we have seen, discussed with the hearing aid industry and internationally recognized experts and compared repeatedly with known information from the literature and existing test methods, although for specific reasons certain details on the tests sometimes differ from standards or tests conducted for other purposes.
The factors tested seem to have reasonable prima facie validity. Since the hearing aid is intended to assist a hard-of-hearing person, substantial amplification over a wide-frequency range related to speech obviously seems important. A low level of harmonic distortion likewise seems highly desirable. With the present state of hearing aids and the recently extreme emphasis upon miniaturization in relation to limitations in the state of the art, though, one certainly cannot expect the low values of distortion which are demanded in high-fidelity music systems or even the moderate amounts tolerated by individuals with normal hearing in many public address systems or in portable transistor radios (particularly with worn-down batteries).

There is also an increasing interest, explained by Mr. Burnett, in measuring intermodulation distortion or the spurious insertion of vibration energy at frequencies (leading to perception of sounds at pitches) corresponding to the sums or differences of true frequencies (or their multiples) in the signal actually present at the microphone (Fig. 7). Speech corresponds to a series of simultaneous bursts of rapidly changing frequencies, with the difference between one word and another similar word often depending primarily upon presence or absence of a brief burst of a particular frequency. Either harmonic or intermodulation distortion leading to the mirage-like impression of a similar burst might thus give a misleading impression of the word to be understood.

Intermodulation distortion might be measured laboriously by applying simultaneously two different frequencies, as in Figure 7, and scanning the rest of the frequency band of interest to measure each intermodulation product, then repeating the process for each of a vast number of other possible pairs of stimulus frequencies. Similar tests could be made with three, four, or even far more stimuli. Clearly a simpler method would be desirable for a practical test. Mr. Burnett has used a method supplying “white noise,” with random distribution of bursts at various frequencies. Then he scans from low to high frequencies a narrow “notch” in which the noise stimuli are suppressed so he can measure energy spuriously appearing in this notch as a result of the intermodulation products resulting from the vast number of spikes of noise energy occurring essentially simultaneously at other frequencies above and below the notch. This method is being tried experimentally in the tests for hearing aids in 1967.

Transient distortion, with bell-like continued “ringing” smearing succeeding pauses and sounds, is so difficult to measure and specify that it is not presently used as a criterion. Nevertheless, transient distortion probably is particularly objectionable. It occurs particularly in outputs of certain aids which seem to display “peaking” of output versus frequency or unusually high amplification or “gain” of output
power compared with input sound near a particular frequency at which the system resonates like a bell.

Other physical factors measured at the National Bureau of Standards and used in scoring seem reasonable, though further refinement is desirable. The considerable differences often noted between three copies of the same make and model of hearing aid, for example, indicate the need for improvements in quality control.

![Diagram](image)

**CONCLUSION**

Hearing of acoustic signals, especially speech, is a complex psychophysiological process at best. Though great progress has been made in surgical or prosthetic treatment of conductive hearing losses, problems of sensorineural losses remain essentially unsolved. Unfortunately, these latter are often more baffling and resistive to amelioration by hearing aids than the conductive losses.

The hearing-aid industry is vigorous, highly competitive, and able to draw upon a wealth of scientific data since Helmholtz and Lord...
Rayleigh. Technological progress available chiefly has been funded for other reasons; for example, printed circuits for World War II proximity fuzes, transistors for telephone, radio, and other electronic circuitry, and now integrated circuits for guided missiles.

There still are serious problems in relating clinical usefulness and weights of physical tests for discriminating among hearing aids and in selecting the most appropriate aid—or binaural aids—for each individual patient. The following papers discuss selected aspects of research on these problems. Finally, we all must remember constantly that hearing aids alone, like other mechanical, electrical, or optical aids for various disabilities, are often necessary but never sufficient conditions for total rehabilitation.